A sustainability assessment method for greenfields, low cost, cement block housing developments on the Cape Flats.

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November 1999

TABLE OF CONTENTS

Acknowledgements

I am most grateful to my supervisor, Richard Hill. This dissertation would not have been possible without his inspiring ideas, meticulous editing and consistent commitment and support. I am also grateful to Dean Ollis and Ken Garman for the part they played in editing this dissertation.

Many persons involved in low cost housing and related fields were consulted during this study. My sincere thanks go to all of these people for their valuable input and time.

This dissertation was funded by the University of Cape Town and the Centre for Science Development.

Abstract

This dissertation describes the development and pilot application of a sustainability assessment method for greenfields, low cost, cement block housing developments on the Cape Flats. The aim of this assessment method is to provide a means for assessing the sustainability of these low cost housing developments.

The sustainability assessment method was developed within the theoretical parameters of sustainable development and sustainable construction. Literature relating to sustainable development, sustainable construction, green building and low cost housing was reviewed for this dissertation. Thirty-two persons involved in low cost housing were consulted during this study. Seven greenfields low cost housing projects on the Cape Flats were investigated. The sustainability assessment method was applied to two case studies in order to assess the sustainability of these two projects and to establish whether the method is a workable assessment tool.

The sustainability assessment method includes three categories, namely technical, biophysical and socio-economic factors of sustainability. Technical factors are focused on the most in this study followed by biophysical and then socio-economic factors. Technical sustainability has been neglected in the sector of low cost housing, and is of pivotal importance in terms of achieving the overall sustainability of these housing projects.

Technical factors of sustainability, such as external coating, ceilings and mortar mix, performed poorly in the assessment. Certain factors relating to biophysical sustainability, especially the efficient use of water and energy, were weak. A socio-economic factor in need of attention is the education and training of beneficiaries of houses around sustainable living practices. Recommendations are made regarding improving the sustainability of greenfields, low cost housing projects on the Cape Flats. It was concluded in this study that the sustainability assessment method is a feasible assessment tool which should be further tested and refined in the field.

List of Figures

List of Tables

List of Photographs

List of Acronyms

BATNEEC	Best Available Technology not Entailing Excessive Costs
BRE	The Building Research Establishment
BREEAM	The Building Research Establishment Environmental Assessment Method
CCA	Copper chrome arsenic
CFCs	Chlorofluorocarbons
CMA	Cape Metropolitan Area
CMC	Cape Metropolitan Council
CIB	International Council for Building Research
CO_2	Carbon dioxide
DEAT	Department of Environmental Affairs and Tourism
DPC	Damp-proof coursing
EIAs	Environmental Impact Assessments
EMP	Environmental Management Plan
IEM	Integrated Environmental Management
iSLP	Integrated Serviced Land Project
ISO	International Organisation of Standardisation
IUCN	International Union for the Conservation of Nature and Natural Resources
MANTAG	Minimum Agrement Norms and Technical Advisory Guide
MPa	Mega Pascals
NBR	National Building Regulations
NGO	Non-government organisation
NHBRC	National Home Builders' Registration Council
PVA	Polyvinyl alcohol
PVC	Polyvinyl chloride
RDP	Reconstruction and Development Programme
SABS	South African Bureau of Standards
UK	United Kingdom
VOCs	Volatile Organic Compounds
WCED	World Commission on Environment and Development

Chapter 1

1. INTRODUCTION

The introductory chapter of this dissertation serves as a preamble to the theoretical framework of the study, which is discussed in Chapter 2. Chapter 1 outlines key tenets and concepts upon which this dissertation is based, as well as the problem statement, aim, and method of this study.

1.1 Context of study

The focus of this dissertation is low cost housing in South Africa, specifically on the Cape Flats in the Western Cape. The study is undertaken within the theoretical parameters of sustainable development and sustainable construction, as outlined below and described in more detail in Chapter 2.

1.1.1 Low cost housing in South Africa

One of the fastest growing sectors of the construction industry in South Africa is low cost housing. Since 1994, the democratic government has embarked on a programme to address the housing shortage in the land – estimated then to be 3 million units. The goal stated at that time was to deliver 1 million new low cost houses by the end of 1999 (Lewis, 1998). Although the rate of delivery has been slower than expected, low cost houses have, and continue to be built, at a rapid rate.

The government's present goal, as stated in the final draft of the National Housing Code, is to deliver houses at a rate of 350 000 units per annum, until the housing backlog is overcome (Department of Housing, 1999). In the Western Cape alone, 32 503 low cost houses were built over the ten month period from 1 April 1998 to 31 January 1999. The aim of the housing authorities is to accelerate this rate of delivery (Herandien, 1999). The figure of 32 503 houses being built over a ten month period translates into more than a hundred low cost housing units being built in the Western Cape per day. The cumulative impacts of the delivery of these houses on the environment is considerable. A key question relating to this is whether or not these low cost housing developments are sustainable.

1.1.2 Background to sustainable development

Sustainable development is a controversial concept. Definitions of sustainable development remain broad, as consensus regarding the details of the meaning of this concept is difficult to achieve. This is primarily due to the different interpretations adopted for this concept. Some stress the importance of ecological sustainability, i.e. the protection of natural systems, and give less emphasis to socio-economic development. Others focus on socio-economic development even if this causes some degradation of the natural environment. Sustainable development, or sustainability (a more recent term), is about balancing these two seemingly opposing emphases so that neither the natural environment nor the socio-economic development of people suffer.

Barrow (1997) asserts that it is difficult to achieve a single, precise definition of the meaning of sustainable development as it is a term which is often used carelessly and to mean different things. Barrow (1997:1) offers a 'rough' definition of sustainable development as being, *"development that maintains and, if possible, improves the long-term condition of the environment and peoples' quality of life"*. Liddle (1994:47) writes that sustainable development is about *" a constraint on present consumption to ensure that future generations will inherit a resource base no less than the previous generation inherited"*.

Barrow's and Liddles's definitions of sustainable development are similar to the more frequently cited definition of sustainable development, put forward in the report, 'Our Common Future' (see section 2.1of Chapter 2) by the World Commission on Environment and Development (WCED). This document describes sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987:43).

Common themes and principles are identifiable in all three of these definitions of sustainable development. Firstly, the needs and quality of life of people, now and in the future, are emphasised. Secondly, there is emphasis on not degrading the natural environment. Thirdly, there is an implication of finding a balance between environmental protection and human needs. These three themes are basic, recurring principles in the theory relating to sustainable development. The application of these three principles of sustainable development to the low cost housing sector in South Africa would translate into the following goal:

> To meet the housing needs of people in such a way that it enhances their quality of life, incurs minimal damage to the environment and ensures that future generations will be able to have their housing needs met in a similar manner.

The seeds of the notion of sustainable development were sown halfway through this century when people began to question the ability of the earth to sustain the affluent lifestyles of the developed world (Hill and Bowen, 1997). Environmental groups began to focus on protecting the biophysical, or natural environment, but overlooked other components of the environment. From this traditional stance, the notion of the environment, and of sustainable development, evolved to incorporate social and economic components into developmental and environmental issues, in addition to biophysical factors. The environmental movement now embraces social, economic and biophysical factors as integral components of any development process which proclaims to be sustainable. A more detailed description of the evolution of the notion of sustainable development within the environmental movement follows in section 2.1.

Policies and legislation relating to the environmental and developmental fields in South Africa have attempted to incorporate the philosophy of sustainable development. In recent years, particularly, there has been a focus on sustainable development. There is a widely supported notion in national development policies and strategies that sustainability in environmental issues encompasses many components, including biophysical, social, economic, cultural and political factors, and that development cannot be truly sustainable if any of these is neglected. Social and economic sustainability particularly have been a focus in developmental and environmental issues in South Africa over the past five years .

However, throughout the formulation of an integrated notion of the environment and sustainable development, little attention has been given to the built component of the environment and the technical sustainability thereof. Technical sustainability relates to the performance and quality of buildings (Hill and Bowen, 1997). The built environment comprises the buildings and infrastructure which humans have constructed in the natural environment. This includes low cost housing, which comprises a significant part of the built fabric in South Africa. Inadequate attention to technical sustainability in the low cost housing sector would result in houses which are poorly constructed, cold and damp. This development would be unsustainable as peoples' needs would not be met adequately and their quality of life would not necessarily improve.

The focus of the low cost housing sector has been on the number of units produced, at the expense of sustainable development (Hopkins, pers. comm., 1999). If the government's goal of sustainability in the environmental and developmental fields is to be achieved, the construction of low cost houses needs to be based on principles of sustainable development, and should include all of the components of sustainability.

1.1.3 Background to sustainable construction and green building

The inadequate focus on the sustainability of the built environment is being recognised by the construction industry (Woolley *et al.*, 1997). In the last five years, internationally, there has been growing concern regarding the impacts of buildings and the construction industry on the environment.

Construction activites and buildings may have adverse impacts on the environnment as they can affect natural systems and the quality of life of humans. Annik *et al.* (1996) note that of all the material resources extracted from nature, 50% are utilised for buildings. In Europe, 40% of energy consumption is building-related. The combustion of fossil fuels in electricity generation has lead to increases in the levels of carbon dioxide (CO_2) and oxides of sulphur and nitrogen in the atmosphere, which have, in turn, led to an increase in the greenhouse effect and acid rain. Due to the effect that poor construction practices have on the biophysical environment and human well-being, they have come under scrutiny.

As a result, the concepts of sustainable construction and green building have emerged in recent years.

Sustainable construction and green building are relatively new fields internationally. Both of these concepts fall within the broader theoretical framework of sustainable development. Kibert (1994) writes that sustainable construction is about creating a built environment which is healthy for humans and based on ecologically sound principles. Rees (1998) proposes that green building is essentially about 'greening' the building industry through incorporating environmental considerations into building practices. Green building and sustainable construction aim to fulfill principles of sustainable development within the construction industry. The emphases of both concepts are on employing ecologically sound, resource-efficient practices and ensuring that built environments are healthy for humans (see section 2.2).

The first international conference on sustainable construction was held in 1994 in Florida in the United States of America (Drager, 1996). Over the past five years this field has grown rapidly and become recognised as a discipline in its own right. Conferences on sustainable construction and green building are held regularly, such as the "Green Building Challenge 1998" conference, held in Canada in October 1998. The International Council for Building Research (CIB) also held a conference on "Construction and the Environment" in Sweden in June last year.

This awakening to the unsustainable impacts of buildings and the construction industry on the environment has had some influence in South Africa, although the focus is somewhat different here. In South Africa, the most common approach is to focus on the sustainability of the human or social element, while the developed world focuses mainly on biophysical issues such as global warming. The tendency in the developed world is to utilise the terms 'sustainable construction' and 'green building' interchangeably, whereas in South Africa sustainable construction is understood to comprise more than green building, in that it encompasses social and economic issues as well as green building issues (Hill and Bowen, 1997). Whatever the central focus of sustainable construction and green building may be, the construction industry, and specifically low cost housing, needs to take cognisance of its contribution to environmental degradation and unsustainable practices, and to consider more sustainable methods of construction.

It is questionable whether construction in South Africa is sustainable in the arena of low cost housing developments. In June 1999, the Housing Minister, Sankie Mthembi-Mahanyle, announced that 400 000 of the 600 000 low cost houses which have been built are substandard (Black, 1999). Recently, the Cape Argus reported on a cement block low cost housing development in Mitchell's Plain, built five years ago, which has been condemned by the Cape Town City Council. Independent assessors found problems with faulty foundations, water seepage, damp floors and walls, cracked walls and leaking roofs (Hood, 1999). The indications are that technical factors of sustainability have been neglected in this housing project.

Sustainable construction in low cost housing can only take place if all of the components contributing to sustainable development are recognised. Social issues relating to sustainability in the construction industry cannot be considered in isolation from technical issues, nor can biophysical factors be considered in isolation from issues of economic sustainability. Furthermore, areas of sustainable construction which have been neglected need special attention. While social and economic factors of sustainability have received priority in the low cost housing sector in South Africa, technical factors have been neglected (Koch, pers. comm., 1999). Technical issues of sustainability need to receive more attention in order to accomplish sustainable low cost housing (Hopkins, pers.comm., 1999; Wiseman, pers. comm., 1999). While the siting of some low cost housing projects has been subject to Environmental Impact Assessments (EIAs), the biophysical factors that have been overlooked in the low cost housing sector relate primarily to the efficient use of energy and water (Johnston, pers. comm., 1999; Rendell, pers. comm., 1999).

Hill and Bowen's (1997) framework of principles for sustainable construction take into account all of the interrelated components of sustainable development and construction, including technical sustainability. This framework consists of process-orientated principles of sustainable construction and four pillars of sustainable construction. The pillars consist of biophysical, economic, social and technical sustainability, containing principles relating to each of these (see section 2.2.2).

Unless the construction industry in South Africa, specifically the low cost housing sector, embraces all of these principles of sustainable development and construction, the government's objective of delivering low cost houses which are sustainable will not be realised.

1.2 Problem statement

There are numerous low cost houses currently being built on the Cape Flats. The focus of the low cost housing sector is on the number of units built and the rate of delivery, often at the expense of the sustainability of the housing units. The potentially adverse impacts of these low cost housing developments are considerable. If they are not built according to principles of sustainable development and sustainable construction, the biophysical environment and the people living in these houses will be negatively affected. (Further detail of the problem statement is given in section 3.3.)

1.3 Aim and objectives of dissertation

The aim of this study is to contribute to the advancement of the field of sustainability in cement block low cost housing on the Cape Flats. This will be achieved through the formulation of a sustainability assessment method, consisting of certain factors against which selected principles of sustainable construction and development can be evaluated.

The objectives of this research are as follows:

- To develop a sustainability assessment method for cement block, greenfields, project-linked low cost housing developments on the Cape Flats (see section 3.2).
- To demonstrate the application of this method through the pilot assessment of two case studies, including the evaluation of the degree to which certain aspects of sustainability have been achieved in these case studies.
- To draw conclusions and recommendations from the application of the method.

1.4 Assumptions and limitations of dissertation

The limitations and assumptions of this study are as follows:

- Time constraints imposed limitations on this project. Sustainability in low cost housing is potentially a vast field of study. Boundaries had to be set for this dissertation, such as identifying a specific geographical area and a certain type of low cost housing development for investigation (see section 3.1).
- This dissertation focuses on certain aspects of sustainability, namely technical followed by biophysical and then socio-economic sustainability, more than others (see section 3.1 and 3.3).
- The investigation and assessment of issues in this project is primarily from a sustainable development perspective. This concept is difficult to define, and broad in nature. Hence, a qualitative, exploratory approach has been adopted to this research as opposed to a quantitative, rigorous approach.
- The researcher is an environmental science student, who does not claim expertise in other disciplines, such as civil engineering or building science.

1.5 Methodology

The research methodology employed for this study included a literature review, the development of a sustainability assessment method and the pilot application of this assessment method to two case studies. This methodology is described below.

i) Literature review

A review of national and international literature was undertaken. The focus of this review was literature relating to sustainable development, sustainable construction and green building. The focus of the literature review on sustainable construction and green building was building materials, methods and practices and the underlying principles of these concepts. Literature on low cost housing and the South African government's policies and legislation relating to low cost housing were also reviewed.

ii) Development of the sustainability assessment method

A sustainability assessment method was developed based on the literature reviewed and information gathered in the field. Seven greenfields low cost housing developments were investigated and thirty-two persons (developers, project managers, contractors and people from non-government organisations (NGOs) and local authorities) involved in low cost housing were interviewed over a period of three months (interviewees included in Appendix A). These people were identified by means of a chain referral technique, whereby one person would suggest that another in the field be contacted. Criteria were developed for a sustainability assessment method for cement block, greenfields low cost housing developments on the basis of the information gathered from the literature, the interviews and site visits.

iii) Application of the sustainability assessment method to two case studies

Two of the seven case studies were chosen for assessment using the method. The basis for choosing these two case studies was the availability of required information (see section 4.1).

Credits were awarded to each criterion, or factor. The awarding of credits was performed by the researcher on the basis of information gathered. The scoring was then analysed, and conclusions were drawn and recommendations given.

This introductory chapter has outlined the main theoretical concepts on which this research is based and discussed the problem statement, aim and methodology of the research. The following chapters describe the theoretical framework of this research, the development and application of the sustainability assessment method, the results of the application of the method and the conclusions drawn and recommendations made as a result of this study.

Chapter 2

2. THEORETICAL FRAMEWORK OF STUDY

The purpose of this chapter is to describe the theoretical premises upon which this dissertation has been developed. This chapter discusses sustainable development, and the major tenets of sustainable construction and green building, as understood internationally and in South Africa. The last section of this chapter reviews an environmental assessment method for buildings which was developed in the United Kingdom, the concepts of which were adopted when formulating the sustainability assessment method.

2.1 Sustainable development

The concept of sustainable development, as it is known today, has evolved over the past fifty years. In South Africa, the emphasis of this concept is different to more developed countries.

2.1.1 Evolution of the concept of sustainable development

The current definitions of sustainable development discussed in Chapter 1 emphasise meeting the developmental needs of people (including improving quality of life where appropriate), protecting the natural environment (thereby ensuring that the prospects of future generations of meeting their needs are not hampered) and maintaining a balance between socio-economic development and the protection of the environment. Mitlin and Satterthwaite (1994) state that the term 'sustainable development' brings together two strands of thought regarding the management of human activities. One strand concentrates on developmental goals and the other on limiting or controlling the harmful impacts of human activities on the environment. The concept of sustainable development thus provides a framework for the integration of development strategies, such as low cost housing, and the protection of the environment.

Since the 1800's, the rise of industrialism globally has had a dramatic effect on the environment. During the last century, natural resources on this planet have been depleted rapidly. The development of science and technology, as well as the burgeoning world population, have contributed to the expending of natural resources through increasing the capacity of the human race to make fundamental changes to the global environment (Haughton and Hunter, 1994). There has been international recognition of a mounting environmental crisis, which has given rise to the concept of sustainable development.

Hill *et al.* (1994) provide a succinct account of the evolution of the notion of sustainable development within the environmental field. These authors note that by the middle of this century, people were becoming concerned with the escalation of environmental degradation and the ability of the earth to sustain the affluent lifestyle of the developed world. Gardner (cited in Hill *et al.*, 1994) notes that enlightened writers, such as Leopold and Carson, introduced the modern environmental movement by advocating that humans should show more consideration for the environment and less for material gain.

The first Earth Day, which occurred as a result of public concern for the environment, was celebrated in the United States of America in 1970 (Fuggle *et al.*, 1992). Hill *et al.* (1994) note further important events in the evolution of the concept of sustainable development. In 1972 the United Nations Conference on the Human Environment in Stockholm formulated the notion of ecodevelopment, positing that socio-economic development and ecological principles should operate together in harmony. In the same year, the Club of Rome published 'The Limits to Growth', which was a document which challenged the pro-growth ideology of previous decades.

However, nature conservation and development were still seen as being in conflict with one another. In 1980, the International Union for the Conservation of Nature and Natural Resources (IUCN) published the 'World Conservation Strategy'. This document heralded a shift away from the traditional separatist philosophy of nature and development towards the integration of conservation and development, where both of these concepts were seen as involving human use of the biosphere (Hill *et al.*, 1994).

The birth of the term sustainable development is commonly attributed to the publication of 'Our Common Future' (commonly referred to as the 'Brundtland Report') in 1987, in which concern for both the environment and development was made explicit. This document stresses that the attainment of social and economic goals of society is integrally connected to the achievement of environmental goals (Hill and Bowen, 1997). The definition of sustainable development in the Brundtland report, as quoted in Chapter 1, is probably the most widely used definition of sustainable development in the environmental field today.

The IUCN updated the 'World Conservation Strategy' in 1991 with a document entitled 'Caring for the Earth'. In this document, sustainable development was defined as development which enhances the quality of human life without exceeding the carrying capacity of supporting ecosystems. In 1992, the United Nations Conference on Environment and Development in Rio de Janeiro focused on the notion of sustainable development, debating which nations were responsible for over-extending the carrying capacity of ecosystems (Hill and Bowen, 1997).

In 1993, an economist named Solow introduced the notion of society's total natural capital. This notion offered a practical and comprehensive step towards attaining sustainability (Hill and Bowen, 1997). Mitlin and Satterthwaite (1994) assert that ideally, there should be no depletion or degradation of natural environmental capital so that the ecological and resource base for human activity can be sustained indefinitely. They state that natural environmental capital can be divided into four categories. The first category, non-renewable resources, includes fossil fuels, minerals, biological diversity and irreplaceable cultural and natural assets. Renewable resources comprise tree and forest products and, within finite limits, water resources. The last two categories of natural environmental capital include the renewable and non-renewable natural sink capacities of local or global systems to break down organic wastes, or absorb or dilute non-biodegradable wastes (without adverse effects), respectively. An example of the former would be the capacity of a water body to break down organic wastes, and an illustration of the latter would be the capacity of the atmosphere to absorb greenhouse gases without a significant negative impact on the climate (Mitlin and Satterthwaite, 1994).

Solow (cited in Hill and Bowen, 1997) argued that development will inevitably include some drawdown of non-renewable resources, and that sustainability should therefore encompass more than the preservation of natural resources. He asserted that substitution possibilities between natural and other forms of capital should be investigated. Other forms of capital could include social or human-made capital, such as factories or education, which could enhance and maintain productive capacity in order that the needs of future generations be met.

Interpretations of the notion of sustainable development are varied and numerous, and will continue to evolve. It will remain a broad concept, characterised by seemingly opposing ideas and meanings. The development versus environment debate, where there is ongoing conflict between the protection of the environment and socio-economic development, will add to the elusiveness of this notion. However, the concept of sustainable development has evolved to a position where there is consensus about the fundamental principles of what comprises sustainable development. The common ground that has been found to date in the theory of sustainable development is highlighted by Hill and Bowen (1997), who state that incongruities of the development versus environment debate of the 1970s and the 1980s have been replaced to some extent by a more integrated notion of sustainable development, which maintains that development should encompass the wise use of natural resources. Once again, the theme of balancing development with environmental protection is evident. The development of any low cost housing projects in South Africa should always be weighed up against the impacts on the natural environment. For the purposes of this dissertation, sustainable development will be seen as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987:43).

2.1.2 Sustainable development in South Africa

The world's urban population more than trebled from 1950 to 1990, rising from 730 million to 2.3 billion. In 1993, at least 43% of the world's population lived in urban areas, with the urbanised population in the developed world being about 73% of the total. In the less developed world, the growth rate of the urban population was believed to have exceeded 7% per year since the early 1980's (Devas and Rakodi, 1993). Today, the world population stands at 6 billion people. By the year 2000, it is estimated that there will be at least 28 mega-cities in the world, with population numbers of at least 8 million each. Twenty-two of these mega-cities will be in less developed countries (Gilbert, 1996).

As cities continue to grow in size, their environmental impacts will continue to be a central theme in the move towards global sustainability (Haughton and Hunter, 1994). Urbanisation, and developments such as low cost housing projects, can have profound effects in terms of transforming nature. Douglas (cited in Haughton and Hunter, 1994) names some of these transformations, or environmental impacts, as being changes to the functioning of local ecosystems, altering natural flows of water, food and materials, site transformations (such as river channel diversion) and pollution. Urban development means that intensive demands are made on environmental resources, such as quarries for building materials and fossil fuels utilised for the production of energy (Haughton and Hunter, 1994). South Africa is no exception to the effects of rapid population growth, urbanisation and urban development. It is imperative that urban development in South Africa, including low cost housing, should operate according to sound principles of sustainable development, in order to ensure that minimal environmental damage occurs and that the needs of present and future generations are met.

In applying sustainable development to the South African context, O'Riordan (cited in Hill *et al.*, 1999) identifies the three principal South African initiatives supporting sustainable development as being:

- economic growth and redistribution;
- social reconstruction and political empowerment of communities;
- environmental policy and protection, including both ecological and cultural components.

These initiatives incorporate important components of sustainable development, i.e. social, biophysical, economic, political and cultural elements.

O'Riordan's view is in keeping with the Reconstruction and Development Programme (RDP) of the South African government, which notes all of these elements. The White Paper on the RDP states that the RDP is a *"policy framework for integrated and coherent socio-economic progress"* which should create a *"sustainable and environmentally friendly growth and development plan"* (cited in Hill *et al.*, 1999).

This is further supported by the clause in section 24 of the Constitution of South Africa (Act 108 of 1996), which states that:

> *"Everyone has the right . . to have the environment protected, for the benefit of present and future generations"* through measures that *"secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development"*.

In principle and in theory, it might seem as if the basic tenets are in place for sustainable development to occur in South Africa. However, while the South African notion of sustainable development definitely includes social and economic factors, sustainability in the built environment, and technical factors thereof, does not receive the same attention as social and economic factors. In order for development to be truly sustainable in the low cost housing sector, all facets of sustainability need to be taken cognisance of and principles of sustainable development need to be embraced by all of those involved in the construction of low cost housing.

2.2 Sustainable construction and green building

As indicated in Chapter 1, sustainable development provides the broader theoretical framework encompassing sustainable construction and green building, internationally and in South Africa.

2.2.1 The international context

Sustainable construction and green building practices internationally seek to fulfil the principles of sustainable development within the arena of the construction industry. Both aim to utilise appropriate building technologies and practices, based on sound ecological principles, which create built environments that favour healthy living and enrich the daily lives of people.

Kibert (1994) identified certain principles of sustainable construction, as summarised in Table 1. He argued that establishing principles of sustainable construction was essential in order to protect natural resources and create a healthy, quality natural and built environment.

1.	Minimise resource consumption.
2.	Maximise resource reuse.
3.	Use renewable or recyclable resources.
4.	Protect the natural environment.
5.	Create a healthy, non-toxic environment.
6.	Pursue quality in creating the built environment.

Table 1: The principles of sustainable construction (Kibert, 1994).

Kibert (1994) stated that the outcome of applying such principles would be the creation of a built environment which is based on environmental awareness and sensitivity.

With these principles as a basis, Kibert (1994) went on to identify specific issues to be taken into consideration in sustainable construction, as indicated in Table 2.

Resources - Energy consumption - Water use - Land use - Materials selection	**Healthy Environment** - Indoor environmental quality - Exterior environmental quality
Design - Building design - Community design	**Environmental Effects** - Construction operations - Life cycle operations - Deconstruction

Table 2: The issues of sustainable construction (Kibert, 1994)

What is evident from both of these tables is that there is an emphasis on the biophysical component of sustainability. Protection of the natural environment, the efficient use of resources and life cycle analyses are central themes. The social element is mentioned in terms of the importance of pursuing quality, healthy surroundings for people, but does not receive the same focus as biophysical factors.

This is the recurring emphasis of sustainable construction and green building in the northern hemisphere, i.e. the focus on building technologies and materials which have minimal adverse impacts on the biophysical environment. Vale and Vale (cited in Woolley *et al.*, 1997) claim that:

> *"a green approach to the built environment involves a holistic approach to the design of buildings; that all the resources that go into buildings, be they materials, fuels or the contribution of the users, need to be considered".*

Woolley *et al.* (1997) emphasise further that green building also considers the impacts of materials used on the indoor air quality of buildings.

The predominant themes of international conferences held last year, such as the "Green Building Challenge 1998" in Canada, were materials, life cycle analyses, embodied energy, indoor air quality and ecolabelling. These are described briefly below.

- Life cycle analyses:

International practice encourages the use of detailed life cycle analyses for each building material utilised. The use of materials such as wood, clay, steel and cement are assessed in terms of the environmental impacts associated with raw material extraction, manufacture, transport, utilisation and disposal.

- Embodied energy:

The calculation of the embodied energy for each raw material has evolved as a sub-discipline of life-cycle analysis. Woolley *et al.* (1997: 171) define embodied energy as *"the term used to describe the total amount of energy used in the raw materials and manufacture of a given quantity of a product"*. Embodied energy is highly significant globally due to the environmental impacts of energy production, which cause global warming (Woolley *et al.*, 1997).

- Indoor air quality:

Indoor air quality of buildings is of major concern in the developed world, especially regarding the emission of volatile organic compounds (VOCs) and inadequate ventilation. These factors can have a detrimental effect on human health.

- Ecolabelling:

Environmental labelling (or ecolabelling) programmes have developed over the past two decades, whereby products are labelled as 'environmentally friendly' if they have been manufactured in a manner which has had minimal adverse impacts on the environment. The earliest of these was the Blue Angel Programme, which originated in Germany twenty years ago. Many such programmes have emerged since, allowing the public to discriminate in favour of goods and services with minimal environmental impacts. These rating systems have progressed to include the assessment of buildings and building materials (Kibert, 1998).

2.2.2 Sustainable construction in South Africa

The development of the field of sustainable construction has taken a somewhat different route in South Africa. While international developments in sustainable construction have focused on the issues referred to above, South Africa has focused on best practice in the construction industry, and the multiple objectives of sustainability, i.e. to achieve social, economic and environmental benefits (Hill, 1998).

During the conference on "Sustainability in the Built Environment" held in South Africa in August 1998, Hill (1998) indicated that, to date, best practice in the construction sector has focused on two issues, namely avoiding development on sensitive sites and on-site environmental management during construction. It was also noted at this conference that the South African notion of best practice is closer to an integrated notion of sustainability than it is in developed countries, especially in the realm of social sustainability (Hill, 1998). Kibert (cited in Hill, 1998) stated that *"(t)his is the first conference I have ever been to on sustainability in the built environment where we are actually talking about sustainability and not just technical, 'green' issues"*.

This emphasis on social sustainability is evident in research involving sustainable construction in South Africa. Drager (1996) developed Kibert's six principles of sustainable construction by adding a seventh principle, i.e. that of promoting socio-economic sustainability. She argued that the fundamental factors of socio-economic sustainability are the participation of affected parties in the design and construction of buildings, the use of labour intensive methods, facilitating skills and capacity building and supporting environmentally responsible manufacturers. In applying these factors specifically to the low cost housing sector, Drager argues that housing should be appropiate to peoples' needs and evoke a sense of ownership among the occupants.

There is reason to be concerned that certain aspects of sustainability, such as social and economic factors, have been emphasised more than, for example, technical sustainability in low cost housing. Given the history of South Africa, it is inevitable that this should happen in order to even the scales of past imbalances. Severe social and economic inequities and injustices were perpetrated under the previous government. This has led to a focus on socio-economic issues in government policies, over and above other aspects of sustainability.

Dalgliesh *et al.* (1997) assert that in the low cost housing sector in South Africa, social and economic sustainability have been emphasised over and above technical and biophysical sustainability, and suggest that a more integrated approach should be adopted in the policy relating to low cost housing in South Africa.

Biophysical aspects of sustainability have not been neglected to the extent that technical aspects have in low cost housing. EIAs have been undertaken in South Africa for over twenty years. The emphasis on protecting the biophysical environment has received some recognition over the past few decades, with the emphases in the construction sector (as mentioned) on avoiding developments in sensitive natural environments, and the mitigation of environmental impacts during construction (Hill *et al.*, 1999).

Technical sustainability has been most neglected in the arena of low cost housing in South Africa. There is evidence of this, where houses are often poorly built and experience problems with damp, cold and excessive maintenance costs. Technical issues of sustainability are considered to be very important in this study, because they have been largely neglected in low cost housing in the past, and because they directly affect the overall sustainability of low cost housing developments.

There is some literature on the construction of low cost housing which offers a more integrated view of sustainability, including technical aspects. Groenhof (1995) suggests that low cost housing developments should be judged in terms of:

- the durability and long term effectiveness of the units;
- the time taken for social upliftment after the developers have left the site;
- the extent of degradation of the natural environment.

It is evident from the above that Groenhof has taken the technical, socio-economic, and biophysical components of sustainable development into account.

Groenhof's work corresponds with Hill and Bowen's (1997) four pillars of sustainable construction, namely biophysical, technical, social and economic pillars, which were referred to in section 1.1. Figure 1 overleaf illustrates the four pillars and principles of sustainable construction.

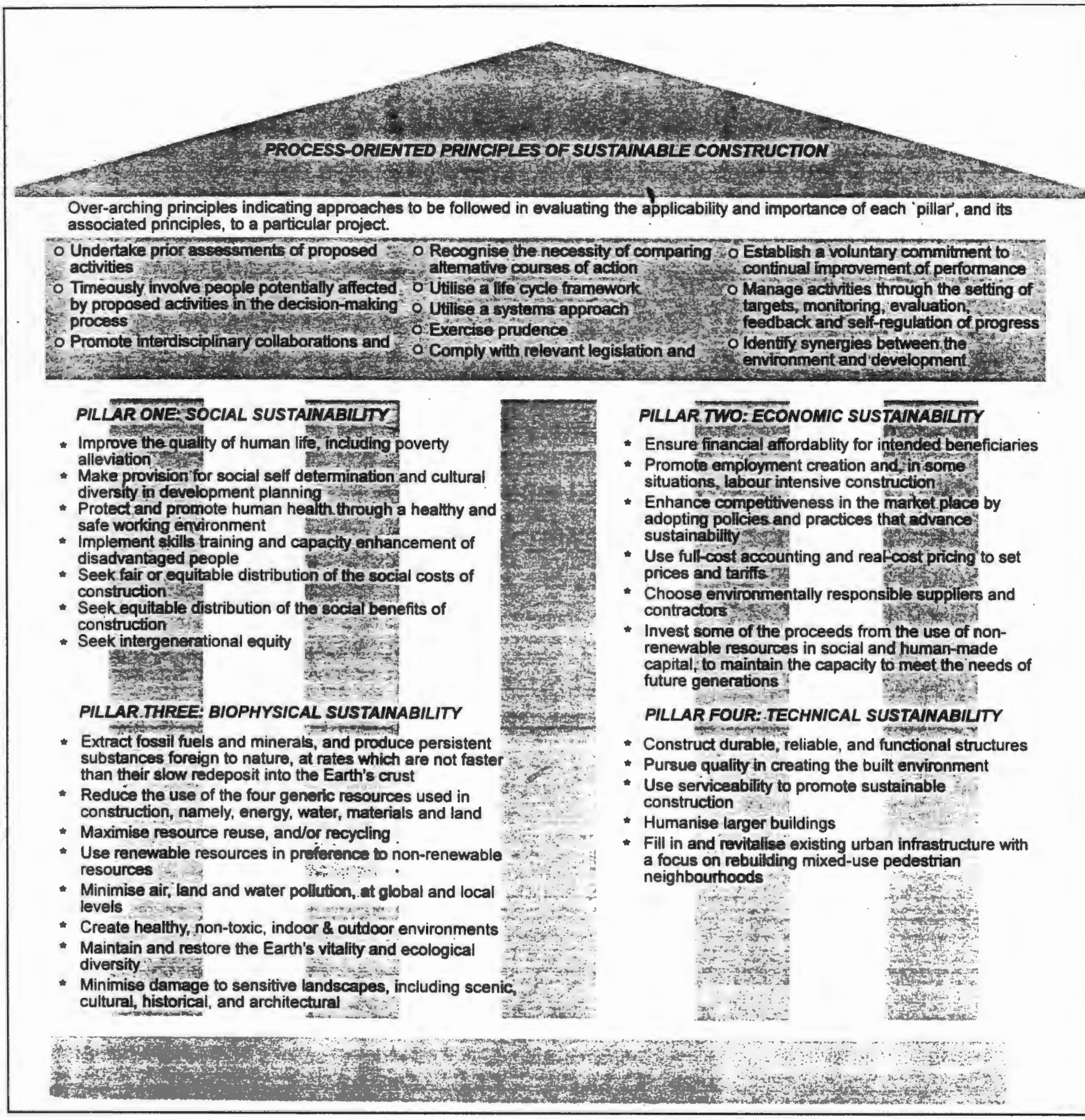


Figure 1: The principles of sustainable construction (Hill and Bowen, 1997)

Hill and Bowen's (1997) framework for sustainable construction in Figure 1 provides a balanced, integrated notion of sustainability. It provides a good point of departure for the assessment of sustainable construction, including low cost housing, in the South African context. A summarised, adapted version of the four pillars of sustainable construction is given in Table 3 below, highlighting the principles which are most relevant to this study on low cost housing.

Pillar 1: Social sustainability - Promote human health and quality of life. - Promote skills training, self determination and cultural diversity. - Ensure equitable distribution of the social costs and benefits of construction.	**Pillar 2: Economic sustainability** - Ensure financial affordability for beneficiaries. - Promote employment creation. - Use environmentally responsible contractors and suppliers.
Pillar 3: Biophysical sustainability - Reduce the use of resources, especially water and energy. - Minimise all forms of pollution, to create a non-toxic environment. - Maximise reuse and recycling, and the use of renewable resources. - Maintain ecological diversity, minimising damage to sensitive environments.	**Pillar 4: Technical sustainability** - Construct durable, reliable, functional structures. - Pursue quality and serviceability in the built environment.

Table 3: The principles of sustainable construction (after Hill and Bowen, 1997).

The pillar of social sustainability is primarily concerned with social justice. This involves addressing the issues of poverty and inequity, through ensuring that the costs of construction are evenly distributed, promoting skills training and enhancing human health and quality of life. The principles of economic sustainability include supporting environmentally responsible suppliers of building materials, creating opportunities for employment, and ensuring financial affordability for beneficiaries. The efficient use of resources, particularly water and energy, is important in achieving biophysical sustainability in the built environment, as is ensuring that environmental impacts during construction are mitigated. The pillar of technical sustainability emphasises that the building of high quality, reliable and functional structures is important in attaining sustainability (Hill and Bowen, 1997).

It is important to note that the boundaries between these pillars of sustainable contsruction are artificial and somewhat fluid. Principles of each pillar invariably incorporate issues which relate to, and have a direct influence on, other pillars. The principles of each of the four pillars of sustainable construction described in Table 3 form the basis for the assessment method described in chapter 3, along with basic tenets adopted from the assessment method described below.

2.3 The Building Research Establishment Environmental Assessment Method

The Building Research Establishment (BRE) of the United Kingdom (UK) has developed an environmental assessment method for assessing the sustainability of various buildings in the UK. The underlying philosophy is that good building design, operation and maintenance will minimise adverse impacts on the environment, and make a major contribution to the achievement of sustainable development.

The Building Research Establishment Environmental Assessment Method (BREEAM) was first launched in the UK in 1990. The primary objective of this scheme was to *"provide authoritative guidance on ways of minimising the adverse effects of buildings on the global and local environments while promoting a healthy and comfortable indoor environment"* (Baldwin *et al.*, 1993:1).

The main aims of the assessment method are to (Baldwin *et al.*, 1993):

- encourage best practice in designing, operating and maintaining buildings;
- set standards and criteria going beyond those required by regulations and laws;
- provide recognition for buildings where adverse environmental impacts have been minimised or reduced;
- raise awareness of the owners, occupants and designers of the adverse impacts of buildings on the environment.

The basis of BREEAM is the assessment of the environmental performance of buildings, measured against a set of criteria. BRE of the UK is responsible for specifying the criteria and methods of assessment used. Wherever a building satisfies these criteria, credits are awarded. Buildings are assessed by independent assessors who are appointed by BRE. Where large numbers of buildings are to be assessed, developers may apply for licences to assess these themselves. High standards of training and quality control are ensured by BRE (Prior and Bartlett, 1995).

BRE assesses various types of buildings, such as supermarkets, industrial units, homes and offices. The basic model is similar, with some adaptations and variations according to the type of building being assessed.

The environmental assessment is carried out at the design stage, and is based on readily available and generally accepted information. Designs are credited where specific criteria or targets are met. Credits are not expected to be gained for every issue assessed (Prior, 1993).

Where sufficient and mandatory criteria are met, and there is satisfactory distribution across the various categories, a certificate is awarded. Overall performance is rated as fair, good, very good or excellent (Prior and Bartlett, 1995). This is effectively an ecolabelling scheme for buildings in the UK.

The environmental issues covered under BREEAM are grouped under three main categories, as described below.

2.3.1 Global issues and the use of resources.

BREEAM emphasises the magnitude of the impact of buildings on the global environment. It cites examples of environmental damage arising from (Prior and Bartlett, 1995):

- energy used during building construction;
- energy consumed during heating, cooling and lighting of buildings;

- chemicals present in, and released during the manufacture of, building materials.

The major thrust of the above are two important principles, namely that energy efficiency should be maximised and fuel should be conserved. This would prevent the depletion of the valuable natural resource of fossil fuels and decrease the production of carbon dioxide and oxides of nitrogen and sulphur, which would limit global warming and the production of acid rain.

The other areas of focus in this category are (Prior and Bartlett, 1995):

- the carbon dioxide produced by the fuel used to manufacture and transport building materials;
- the production of chlorofluorocarbons (CFCs), mainly as refrigerants in air-conditioning systems, which contribute to the depletion of the ozone layer;
- the use and depletion of valuable resources such as wood, brick and stone;
- the design of buildings that would allow 'waste' such as paper and glass to be recycled more easily and water to be used more efficiently.

2.3.2 Local issues

There are two main issues in this category. The first relates to the development of sites, which is linked to site selection and layout. This can have direct impacts on local wildlife and scenery. Consideration of transport requirements should be taken into account here. The second issue concerns Legionnaire's disease (similar to pneumonia), caused or exacerbated by poorly maintained wet cooling towers in air-conditioning systems.

The other factors mentioned under local issues are (Prior, 1993):

- local wind effects caused by the buildings;
- noise emissions;
- the re-use of previous building sites.

2.3.3 The indoor environment and health

The major concern in this category is indoor air quality. Pollutants of concern, which may occur indoors as a result of usage of certain materials and building methods, are as follows (Prior and Bartlett, 1995):

- VOCs such as formaldehyde, wood preservatives and paints (see section 3.4.4);
- living organisms, such as bacteria, moulds and dust mites;
- particulates and fibres, such as asbestos and human-made/artificial mineral fibres;
- radon, combustion products and lead.

Certain concepts and themes of BREEAM have been adopted and applied for the purposes of this study. Firstly, the concept of developing an assessment method to evaluate the environmental sustainability of certain buildings has been adopted. Secondly, the assessment method developed in this dissertation has been arranged in certain categories. These categories differ to those of BREEAM, as they have been chosen according to what is relevant to low cost housing in a developing world context. Thirdly, specific factors within each category, which affect the sustainability of the buildings under scrutiny, have been identified. Fourthly, the awarding of credits occurs where these factors are complied with. Fifthly, certain themes from BREEAM are adopted for the sustainability assessment method, such as the impacts of buildings on the natural environment, energy consumed by buildings, the health and well-being of occupants and indoor air quality. Obviously, themes which were not considered relevant to this dissertation were not included in the assessment method, such as the production of CFCs and factors affecting Legionnaire's disease (as these are associated with buildings with air-conditioning systems).

Chapter 2 has outlined the theoretical bases of this study. It is evident that important concepts adopted for this dissertation are based on theory relating to sustainable development, sustainable construction and BREEAM. A synthesis of these concepts has provided the foundation upon which the sustainability assessment method described in Chapter 3 has been developed.

For the purposes of this study, the term 'sustainability' will be utilised when referring to issues relating to sustainable development and sustainable construction. Sustainability encompasses developmental activities that do not impact adversely on the natural environment, implying that there is a commitment to sustaining natural environmental capital combined with a commitment to ensuring that peoples' needs are met, now and in the future.

Chapter 3

3. FORMULATION OF THE SUSTAINABILITY ASSESSMENT METHOD

This chapter explains how the sustainability assessment method was developed. It describes the low cost housing schemes for which the method has been developed and the theoretical components of the method. The categories of the method, the rationale behind the selection and weighting of these categories, the selection of factors within these categories and the awarding of credits to factors are explained.

3.1 Introduction

Using ideas and concepts from the theoretical framework discussed in chapter 2, as well as other relevant information as described in section 3.4, a sustainability assessment method for low cost, cement block housing on the Cape Flats has been formulated. As indicated in section 2.3, the method assesses building projects from a sustainability perspective. Credits are awarded in certain categories according to the fulfilment of certain criteria / factors. The credits are added together to obtain an overall total for the project.

There are many factors that could have been included in the development of a method that assesses the sustainability of low cost housing projects. It was thus necessary to set boundaries for this study, as described below.

- Firstly, only low cost housing developments in the geographical area of the Cape Flats were considered.
- Secondly, a specific type of low cost housing development scheme was focused on, namely, greenfields, project-linked schemes, constructed with cement blocks. Projects within these schemes have distinguishing characteristics. As greenfields projects, they are developed from a stage of no preceding development, where no services have been installed prior to the project. As project-linked developments, the developer, as opposed to, for example, an individual or a NGO, applies for the housing subsidy. This results in the mass production of houses in these schemes at a rapid rate.

- Thirdly, the assessment method focuses on certain aspects of sustainability more than others. Technical sustainability receives the most focus, followed by biophysical and then socio-economic sustainability. The rationale behind the weighting of these aspects of sustainability is explained in section 3.3 of this chapter.
- Fourthly, this study does not focus on embodied energy, life cycle analyses or ecolabelling. Although these fields are growing internationally, they remain relatively undeveloped in South Africa at this stage, especially in the building and construction sectors.

3.2 Greenfields, project-linked housing schemes

As indicated earlier, so-called greenfields, project-linked developments include the installing of services as well as the construction of the top structures. In an effort to make low cost housing affordable to the beneficiaries, the government provides a subsidy of R16 000 per beneficiary, plus R2 400 per unit for extra service costs incurred in the Western Cape area. Certain conditions, such as the sandiness of the Cape Flats, make it difficult to install services such as roads and water pipes without incurring extra costs. In order to qualify for a full subsidy of R16 000, beneficiaries should earn an income of less than R1 500 per month.

The top structure of the typical housing unit of these developments varies in size from $18m^2$ to $28m^2$. It costs approximately R8 000 to R9 000 to build one top structure (the balance of the subsidy being utilised to install services). The units are very basic and consist of the foundations and floor, single-leaf (one row) cement block walls, steel-framed doors and windows and fibre cement (or sometimes steel) roofing. The houses usually consist of one room with a washtrough, and a bathroom with a toilet. Obviously, cost constraints play a major determining role in the materials and methods utilised in these housing units. Figure 2 illustrates the basic components of these low cost houses in more detail.

Roof

- Fibre cement or metal sheeting roof
- Roof support: wooden purlins

Doors and Windows	Walls and Mortar	Sanitary fittings
- Windows (steel frames) - External doors: wood (steel frames) - Internal doors: masonite (steel frames)	- Single leaf walls (cement blocks) - Mortar consisting of cement and sand - Cement-based or acrylic external paint	- Polyvinyl (PVC) toilet pan and cistern - PVC washtrough

Foundations and Floor Slab

- Strip footing or raft foundations - Damp proof coursing - Concrete Slab Floor

Figure 2: The components of a typical low cost house in a greenfields, project-linked scheme.

Photograph 1 depicts what houses in most greenfields, project-linked schemes look like.

Photograph 1: A housing unit in a typical greenfields, project-linked scheme

3.3 Problem statement

As outlined in section 1.2, greenfields, low cost, cement block housing developments are being built at a rapid rate on the Cape Flats in the Western Cape. There is political pressure on housing authorities to deliver low cost housing for people as expeditiously as possible. Principles of sustainability are often not applied in the design and construction of these housing projects. If these principles are not applied, the natural environment will not be protected and the needs of beneficiaries will not be adequately met.

A number of low cost housing developments on the Cape Flats are not sustainable (see section 1.1.3). Moreover, certain areas of sustainability have been neglected. Technical factors have been the most neglected. Many cement block low cost houses on the Cape Flats are not durable or reliable and manifest problems with leaking of rainwater, dampness, coldness and cracking walls. These factors impact directly on the social and economic sustainability of the housing projects, causing health problems and creating extra expenses for the beneficiaries of the houses. Because of the underpinning role that technical factors play in achieving sustainability in cement block low cost housing, and because these factors have been the most neglected, they have been given the most attention in this dissertation.

Certain biophysical factors of sustainability, namely the efficient use of water and energy, have not received sufficient attention in low cost housing projects while other factors, such as environmental investigations, have received some attention. Socio-economic factors relating to sustainability in low cost housing have received the most attention in these projects. After technical factors of sustainability, biophysical and then socio-economic factors are emphasised in this study. The focus of this research is therefore the inverse of the current situation where socio-economic factors have, typically, received most attention, followed by biophysical and then technical factors of sustainability. This focus is further illustrated in section 3.4.2, where the allocation of credits in the sustainability assessment method to the technical, biophysical and socio-economic factors is roughly a half, a third and a sixth of the total credits of the method respectively (see table 5).

Technical aspects, such as the quality and durability of buildings, are significant when assessing the sustainability of low cost housing, as they have a direct impact on economic and social factors, such as the maintenance of units and the health of occupants. The National Housing Act (107 of 1997) emphasises that low cost housing should provide adequate protection against the elements. While making houses more habitable might seem like a social concern, it requires the application of technical knowledge and skills (Hill and Bowen, 1997). If such skills are not applied, it would be impossible to accomplish healthy living environments, and other conditions of sustainability. Because of the pivotal role technical factors play in achieving the overall sustainability of low cost housing, and because they have been neglected, technical factors are a central focus of the sustainability assessment method, and have been allocated 67 out of 140 credits.

Since the early 1970's, attention has been given to biophysical factors of sustainability in development projects through the implementation of EIAs. The Integrated Environmental Management (IEM) Guidelines (1992) and the EIA regulations (promulgated in September 1997 under section 21 of the Environmental Conservation Act 73 of 1989) are examples of systems that aim to protect the biophysical environment. Arguably, biophysical issues of sustainability have not been as neglected as technical sustainability in low cost housing, and there are systems and processes in operation which aim to protect the natural environment. However, water and energy efficiency are components of biophysical sustainability which need more attention in low cost housing. It should be stressed that even though biophysical issues have been allocated a slightly smaller weighting than technical issues, biophysical sustainability remains a crucial component of sustainable development, as the degradation of the natural environment would make the goal of sustainable development impossible to achieve. Biophysical factors have been allocated 51 out of 140 credits in the sustainability assessment method.

Systems and policies have been put into operation over the past five years in South Africa to ensure that social and economic considerations are included in all planning and development projects. For example, the Development Facilitation Act (Act 67 of 1995) and the Local Government Transition Act (as amended by Act 97 of 1996) both aim primarily to address the physical, social and economic needs of local communities and to ensure that adequate public participation occurs in all development projects (Hill *et al.*, 1999). Socio-economic processes and considerations are considered an integral part of development projects, including low cost housing, in South Africa today and are not neglected components of sustainable development (Dalgliesh *et al.*, 1997). Socio-economic factors have been allocated 22 out of 140 credits in the assessment method.

The sustainability assessment method supplements the policies, laws, regulations and procedures which are already in place. The method should be considered in this context, where its function is to supplement and build upon, and not replace, existing systems.

The emphases on the different areas of sustainability, as explained above, form the basis for the categories of the sustainability assessment method, as explained below.

3.4 The sustainability assessment method

This section describes in detail how the sustainability assessment method was forumlated. It discusses the categories of the method, the rationale behind the selection of factors in the method, and the allocation and awarding of credits to these factors.

3.4.1 Categories of the assessment method

The sustainability assessment method is divided into three categories, two of which contain sub-categories. These categories and sub-categories are indicated in Table 4 below.

Technical Factors	Biophysical factors	Socio-economic factors
- Building materials and methods - Quality control	- Energy efficiency - Water efficiency - Environmental investigations, policies and systems	(No sub-categories)

Table 4: The categories and sub-categories of the sustainability assessment method

The categories and sub-categories of the assessment method take into account prevalent themes in the literature, specifically those of sustainable construction, namely biophysical, social, technical and economic sustainability. Social and economic factors have been grouped together, under the category of 'socio-economic factors'. It is common practice in developmental literature to group social and economic factors together into one category pertaining to socio-economic issues, as these issues are interrelated.

The literature review undertaken for this research and observations in the field indicate that the most important issues relating to technical factors of sustainability in cement block, low cost housing on the Cape Flats are the building materials and methods utilised, and the quality control of these methods and materials. In the same way, the efficient use of water and energy resources are significant issues in terms of achieving biophysical sustainability. Research into the potential environmental impacts of housing developments, as well as implementing environmental policies and systems during construction, are also considered important issues in ensuring the biophysical sustainability of projects. No sub-categories were used for socio-economic factors as this is a smaller category of the assessment method. Most of the socio-economic factors of this method relate to the education and training of beneficiaries.

Table 5 indicates the weighting (in terms of the credits allocated) of each of the three categories in the sustainability assessment method, namely technical, biophysical and socio-economic factors.

Category	**Credits allocated**
Technical factors	67
Biophysical factors	51
Socio-economic factors	22
TOTAL:	140 credits

Table 5: The weighting of the categories in the sustainability assessment method

As previously indicated, it became evident during the literature survey that, in the low cost housing sector in South Africa, issues of technical sustainability have received little attention, followed by biophysical factors and then socio-economic factors, the latter of which has been the focus of sustainable development in South Africa over the last five years. Based on this, the category of technical sustainability has received the most weighting in the assessment, followed by biophysical and then socio-economic factors.

3.4.2 Selection of factors and allocation of credits to factors

The factors, or issues, in each category of the method have been selected on the basis of their influence on the sustainability of low cost, single leaf cement block housing in greenfields projects on the Cape Flats. Each factor relates directly to a principle, or principles, of technical, biophysical, social and economic sustainability, as described in chapter 2 of this dissertation.

The basis for the allocation of credits to factors is indicated in the schema in Table 6.

Number of credits to be allocated to factor	Significance rating for allocation of credits
1 to 2	Where a factor is of low significance in terms of its contribution to the sustainability of the housing project.
3 to 4	Where a factor is of medium significance in terms of its contribution to the sustainability of the housing project.
5 to 6	Where a factor is of high significance in terms of its contribution to the sustainability of the housing project.

Table 6: Schema indicating basis on which credits were allocated to factors

Each factor in the sustainability assessment method was allocated credits on the basis of the schema in Table 6. Examples of factors having low significance in terms of the contribution they make to the overall sustainability of a housing project would be the application of gloss enamel to window and door frames, or the application of a silicone sealant over roof screws. Factors which are likely to have a medium contribution to the sustainability of housing projects include, for example, the addition of a moisture inhibitor to mortar or the implementation of innovative ideas around the management of waste in these projects. Examples of factors which are highly significant in terms of their contribution to the overall sustainability of low cost housing projects include the undertaking of an EIA, plastering of the housing units or implementing a minimum number of educational workshops, relating to sustainable living practices, with beneficiaries.

3.4.3 Awarding of credits to factors

In terms of awarding credits in this assessment method, the user of the method needs to assess whether or not each factor has been satisfied such that the potential credit/s can be awarded. This would be best achieved through site visits where the assessor can surmise, through direct observation, whether or not the credits are deserved. This may be obvious for some factors, for example, in the case of the installation of ceilings or the plastering of the walls of units. However, very often, required information about factors cannot be acquired through a site visit and has to be obtained through secondary sources. These sources typically include building specifications and other relevant written information, and interviews with knowledgeable persons, such as the project manager or the building inspector/s. While this information may not be as reliable as first hand observation (for example, one cannot see whether mortar has a moisture inhibitor added to it or not), it may be the only means of assessment available. In some instances, it may be useful to interview suppliers of materials, such as cement block manufacturers.

The following three sections, dealing with technical, biophysical and socio-economic factors respectively, describe the allocation of credits to factors (underlined and in italics), motivate and explain why each factor is important in terms of sustainability (in normal font) and suggest how to recognise whether or not a factor should be awarded credits (in italics).

3.4.4 Technical factors

Table 7 below indicates the technical factors of the sustainability assessment method and the number of credits allocated to each factor (see section 4.2 for a table with all factors). The factors are divided into two sub-categories, namely building materials and methods and quality control.

A. TECHNICAL FACTORS (67 credits) **1. Building Materials and Methods** ***(Maximum possible credits: 59)***
• **Cement blocks** ***(Maximum possible credits: 9)***
3 credits for the use of cement blocks which have a strength of at least 3.5 Mega Pascals (MPa).
3 credits for the use of cement blocks with a high moisture resistance.
1 credit each for cement sill blocks, precast concrete thresholds and/or weatherbars installed at the front doors.
• **Mortar mix and application** ***(Maximum possible credits: 18)***
3 credits for the use of mortar with a mix of cement:lime:sand in a 1:1:6 ratio.
3 credits for the addition of a moisture inhibitor to the mortar.
3 credits for the use of the pointing method to finish off the mortar joints properly.
3 credits for the use of the bagging method to finish off the mortar joints and application properly.
3 credits for applying and passing the Minimum Agrement Norms and Technical Advisory Guide (MANTAG) test for moisture penetration to the north-facing wall.
3 credits for allowing houses to dry out sufficiently before occupation.
• **Foundations and damp-proof coursing (DPC)** ***(Maximum possible credits: 6)***
2 credits for the use of DPC which is at least 250 microns thick.
2 credits for DPC which is at least 150mm above the level of the surrounding ground.
2 credits for the use of a step brick in the foundations.
• **External coating** ***(Maximum possible credits: 6)***
4 credits for use of skimplaster or similar product on all external walls, **or**
4 credits for the application of conventional plaster on at least the weather-facing external walls, **or**
6 credits for the application of conventional plaster on all external walls.
• **Roofing and ceilings** ***(Maximum possible credits: 14)***
5 credits for installing ceilings.
2 credits for construction of dual-pitched roofs.
3 credits for roof overhangs of at least 400mm on the weather-facing side of the houses.
3 credits for roof overhangs on all four sides of houses of at least 300 mm.
1 credit for applying silicone or a similar sealant over the roof screws.
• **Frames for doors and windows** ***(Maximum possible credits: 4)***
1 credit for installing galvanised steel door and window frames.
1 credit for applying an undercoat and gloss enamel overcoat to door and window frames.
1 credit for applying silicone or a similar sealant around the window frames.
1 credit for applying silicone or a similar sealant around the door frames.
• **Wood for doors** ***(Maximum possible credits: 2)***
2 credits for using saligna as opposed to pine external doors.

2. **Quality Control** ***(Maximum possible credits: 8)***
1 credit for inspection of houses by municipal inspectors on a sample basis, **or**
2 credits for inspection of houses by municipal and contractor's inspectors on a sample basis, **or**
5 credits for inspection of houses by municipal and contractor's inspectors on an individual basis and at specified stages of construction.
1 credit for complying with all sections of the National Building Regulations (NBR).
2 credits for using contractors who are registered with the National Home Builders Registration Council (NHBRC).

Table 7: Technical factors of the sustainability assessment method.

A total maximum score of 67 credits is potentially obtainable for the category of technical factors, comprising 59 credits for building materials and methods and 8 for quality control. The sub-sections below describe the rationale behind the selection of factors and their allocation of credits.

i) Building materials and methods

Building materials and methods relate directly to the pillar of technical sustainability, and have an influence on other components of sustainability. Methods and materials utilised have a direct impact on the reliability, quality, durability and long term financial affordability of these housing units.

The National Norms and Standards document for low cost housing states explicitly that:

> "*(a)ny building . . must be designed to provide strength, stability, serviceability and durability for the life of the structure, in accordance with accepted principles of engineering design and construction practice*" (Department of Housing, 1998:4).

This requirement is important in terms of the economic, social and technical sustainability of low cost housing. Projects where housing is poorly constructed, so that occupants continually have to pay out monies in order to maintain their units in a habitable state, demonstrate short-sightedness of those responsible for the housing developments.

The building methods and materials which are considered important in this research in terms of achieving technical sustainability in greenfields, cement block, low cost houses are cement blocks, mortar mix and application, foundations and damp-proof coursing, external coating, roofing and ceilings, the frames for doors and windows and wood used for the doors.

- **Cement blocks**

It is currently generally accepted amongst proponents of low cost housing that the use of single leaf cavity cement blocks for houses in greenfields projects is the most viable option. A major determining factor is cost constraints. Construction using cavity walls, double leaf walls or clay bricks would prove too expensive (Koch, pers. comm., 1999; Malotane, pers. comm., 1999; Wiseman, pers.comm., 1999). Typically, in low cost housing, the 140mm or 190 mm cement cavity block is used for external walls and the 90mm block for internal walls. The characteristics and properties of the 140mm and 190mm block are similar (April, pers.comm., 1999; Koch, pers.comm., 1999).

Low (1996) provides the following arguments for use of single leaf construction with cement blocks:

- In the lower price range of the housing market, the cost of the walls alone of a house of $25m^2$ can amount to 30% of the total construction (material and labour) costs. Single leaf walls are significantly cheaper to construct, due to the larger building unit.
- Cavity walls cost 40% more to construct than single leaf walls.
- Due to improved technology, especially in damp-proofing and paints, it has become possible to build acceptable houses using single leaf walls.
- The quality of labour skills required for laying single leaf cement blocks is not as high as the other options. Labour costs are therefore reduced.
- The bigger building blocks result in fewer joints, which reduces the risk of moisture penetration and reduces the amount of mortar used.
- Maximum floor area is obtained due to the reduced wall thickness of a single leaf wall. Furthermore, an additional $1.4m^2$ can be obtained in a $25m^2$ house when using 140 mm blocks as opposed to 190 mm blocks.

Further advantages of using blocks made of cement are cited by Stulz and Mukerji (1993):

- Cement blocks can achieve high strengths if they consist of the right mix.
- They are not susceptible to swelling or shrinkage.
- Cement block houses, as opposed to more traditional structures, are often percieved as having high prestige value by the communities that inhabit them.

There is also the option of the 140mm blind or closed cement block – so-called as the top of the block is closed (with a central cavity). All of the major brick manufacturers produce these blocks, which cost 6% more then the 140mm cavity block. There is a strong argument for the use of the closed block, as opposed to the cavity block. Cavity blocks require shell bedding, whereby mortar is applied on the edges of the blocks, which in theory should provide sufficient moisture resistance. However, in application, the mortar tends to slide into the cavities, thereby exacerbating moisture penetration. With the closed block, this would not occur. Tests have been conducted which support the notion that the closed block is more effective in terms of resisting moisture penetration (Koch, pers. comm, 1999; Low, 1997). Theoretically speaking, however, this is debatable as with the blind block, there is one straight mortar membrane for the moisture to seep through – making moisture penetration more likely to occur (Molloy, pers. comm., 1999). It should also be noted that although the cost of the closed block is more, the amount of mortar wasted in the use of cavity blocks might balance this out (Koch, pers. comm., 1999).

The healthy debate about which masonary unit is most suitable will continue. For the forseeable future in the Western Cape, cement blocks are likely to be the basic building blocks – especially in greenfields, project-linked schemes. This is also due to the fact that the materials used in the cement block, namely sand, cement and fine aggregate, are readily available in the area. A crucial factor is that whatever blocks are used, their properties in terms of moisture suction and resistance are paramount, as this affects moisture penetration.

Low (1996:1) warns that there are potential problems associated with construction using cement blocks in single leaf walls. He writes that, *"this form of construction is susceptible to moisture penetration and special precautions are necessary to prevent this"*. This problem cannot be over-emphasised, especially when attempting to ensure the sustainability of low cost housing. It is vital to prevent moisture penetration, especially in the Western Cape, which has cold and wet winters. Dampness can reduce quality of life and cause high levels of discomfort for occupants of low cost houses. Some of the problems associated with moisture penetration and dampness in homes are as as follows (Ward and Borchers, 1999) :

- Dampness can cause or exacerbate respiratory illnesses.
- A lot of heat is 'wasted' when heating a damp house, as water in the air is evaporated before the house starts to warm up.
- Dampness enhances the growth of mould, which can be detrimental to the health of occupants and damages materials that the house is made from.

The level of dampness in a house is directly related to the quality of the blocks, mortar and workmanship.

3 credits for the use of cement blocks which have a strength of at least 3.5 MPa (Mega Pascals).

Good quality blocks have a more dense composition and are stronger than poorer quality units (Low, 1996). Strength and density are related to the porosity, and hence the moisture resistance, of blocks. The technical sustainability of the housing units would be compromised if blocks of an inferior strength to 3.5 MPa were utilised. The breakage rate for cement blocks when they are unloaded should be less than 2 % (Johnston, pers. comm., 1999; Schreuder, pers. comm., 1999; Wiseman, pers.comm. 1999).

Information relating to the strength of cement blocks should be obtainable from building specifications or the block manufacturer.

<u>3 credits for the use of cement blocks with a high moisture resistance.</u>

The South African Bureau of Standards (SABS) 0400-1990 document states in section K3 that:

> " *Any wall shall be so constructed that it will adequately resist the penetration of water into any part of the building where it would be detrimental to the health of occupants or to the durability of the building.* "

This regulation requires that walls are constructed to prevent the penetration of water into houses. Damp, leaking buildings have a direct effect on the quality of life of the occupants. Moreover, extra maintenance and heating costs will be incurred by the beneficiaries.

Due to the granular and porous nature of cement blocks, capillaries often form part of their structure. Unless the blocks are carefully designed, these capillaries will conduct moisture readily (Low, 1996). Moisture resistance is determined by the mix design, or ratio, of the sand, cement and aggregate which goes into the blocks, as well as the quality of ingredients. It is often difficult to access information about the mix used by block producers, as it may be regarded as a trade secret (Koch, pers.comm., 1999). Western Cape sands typically lack the necessary fine aggregate component. The aggregate particles are often not compacted closely together, encouraging the formation of capillaries. This makes the 'perfect' mix for truly impermeable cement blocks (maximum density and minimum capillary action) difficult to attain (Low, 1996; Wiseman, pers. comm., 1999).

There are chemicals which can be added to cement block mixtures to reduce capillary action. The addition of such a waterproofing agent to retard moisture penetration is very important. The project manager or contractor should at least check whether or not a waterproofing agent was added to the blocks during their manufacture. Proof of this should be obtainable from the supplier. If all of this information is not readily available from the supplier, the contractor or project manager could undertake a simple test for moisture resistance, as described below.

About 4 blocks should be randomly selected from a batch of delivered blocks. They should be placed in a tray of water 10 mm deep. Blocks with good moisture resistance will take in water no higher than 40 mm (Low, 1996).

The moisture resistance of blocks can be established through information obtained from the block manufacturer or by applying the test described in the paragraph above.

There are alternatives to the conventional method of building with cement blocks. The student was informed of a project where the alternatives of closed block and dry-stack methods have been utilised. Closed cement block systems were described earlier. Dry-stacking is a mortarless form of construction involving stacking interlocking cement blocks in rows. There are a number of other alternatives. Given the availability of sand on the Cape Flats, some would argue that sand-stacking, whereby sacks are filled with sand and then stacked and plastered, is the most sustainable means of building low cost houses. This, and the dry-stacking method, have the further advantage of not needing skilled labour, as in block-laying. It is important to note that these alternatives are arguably better suited to schemes where beneficiaries are actively involved in the building process (such as consolidation subsidy projects), as opposed to project-linked, greenfields schemes where units are mass-produced by a developer.

1 credit each for cement sill blocks, precast concrete thresholds and/or weatherbars installed at the front doors.

The use of cement sill (sloping) blocks or precast concrete thresholds at the front doors, which slant downwards and away from the doors, prevents driving rain or water from entering beneath the doors into the houses. Weatherbars on the base of front doors also serve to divert rain and water away from the dwelling. At the very least, there should be a precast concrete threshold at the outside foot of the front door, which ensures that water will be diverted away from the front door. The threshold has a dual function - it also prevents the doorframe from buckling inwards at the bottom. Ideally, a wooden weatherbar at the base of the front door as well as sill blocks and/or a concrete threshold should be installed. (Malotane, pers. comm., 1999; Schreuder, pers. comm., 1999).

This factor can be best assessed through direct observation during a site visit.

- **Mortar mix and application**

It is unanimously agreed that the quality of mortar used has a direct impact on moisture seepage through walls (April, pers. comm., 1999; Koch, pers. comm, 1999; Ncdlona, pers. comm., 1999). Mortar is highly susceptible to moisture penetration if it is not properly mixed and applied. It is a crucial component in attaining durable and functional structures in low cost housing.

All of the factors of this sub-section can be assessed through a site visit/s during construction, reading of building specifications and/or interviews with the project manager.

3 credits for the use of mortar with a mix of cement:lime:sand in a 1:1:6 ratio.

The ingredients of mortar should be cement, lime and sand in the following ratio: 1 (cement): 1 (lime): 6 (sand) (Koch, pers. comm., 1999; Schreuder, pers. comm. 1999; Wiseman, pers. comm. 1999). (Lime is a crucial element, as its superfine qualities assist in sealing off capillary action (Koch, pers. comm., 1999; Low, 1996). However, it is rarely utilised due to the extra costs involved (Wiseman, pers. comm., 1999).

3 credits for the addition of a moisture inhibitor to the mortar.

A moisture control admixture which reduces moisture penetration should be specified and added to the mortar by the contractor. Most of these additives contain silicone, which repels water (Koch, pers. comm., 1999).

3 credits for the use of the pointing method to finish off the mortar joints properly.

Builders should finish off mortar joints using a pointing tool and method. This would compact the mortar more effectively, thereby making it less porous and less susceptible to water seepage and penetration (Wiseman, pers. comm., 1999).

3 credits for the use of the bagging method to finish of the mortar joints and application properly.

In order to achieve a quality finish, the bagging method should be applied whereby mortar is smoothed over the entire wall, using a sponge-like applier. This achieves smoothness and consistency of the mortar joints, thus decreasing probability of moisture penetration and allowing the external coating to cover the joints more effectively (Schreuder, pers. comm., 1999).

3 credits for applying and passing the Minimum Agrement Norms and Technical Advisory Guide (MANTAG) test for moisture penetration to the north-facing wall.

This condition requires external walls of a random sample of housing units to pass four hours of the KK-17 of SABS 0400-1990 test. This involves spraying the wall evenly with water at a certain pressure (equivalent to 40 – 50 mm of water per hour) for a stipulated time (Low, 1996). Applying and passing this test would be a useful indicator of the moisture resistance of the units.

3 credits for allowing houses to dry out sufficiently before occupation.

Leaving the housing units to stand unoccupied in order for the mortar and concrete in the walls and floors to dry out is important in terms of ensuring that the houses are properly dry before the beneficiaries move in. If the occupants move in prior to this, the future damp-proofing of the houses is likely to be compromised. The sufficient drying out of the units requires a period of approximately 5 windy, sunny days. This is, however, difficult to achieve practically, especially in greenfields projects, where there is pressure from the occupants to move in as soon as possible, and where illegal occupation poses an ongoing threat (Hopkins, pers. comm., 1999; Schreuder, pers. comm., 1999).

- **Foundations and damp-proof coursing**

Strongly compacted and compressed foundations are of vital importance in low cost houses, and have a direct bearing on the long-term structural durability of the units. Furthermore, adequate protection, in the form of damp-proof coursing (DPC) in the foundations, is important for protection against rising damp and other forms of moisture penetration.

Unless a site visit during construction of foundations can be undertaken, the factors in this sub-section can be evaluated by perusing building specifications and interviewing project managers.

2 credits for the use of DPC which is at least 250 microns thick.

If the DPC is not of sufficient thickness, moisture penetration may occur (Wiseman, pers. comm., 1999). A thicker DPC also enhances the mechanical strength of the membrane.

2 credits for DPC which is at least 150mm above the level of the surrounding ground.

The correct positioning of the DPC is significant as this ensures that moisture will not seep into the walls. Situating the DPC at least 150 mm above the ground will also ensure that rising damp into the house is reduced (Ward and Borchers, 1999).

2 credits for the use of a step brick in the foundations.

Figure 3 indicates a step brick, which will ensure that descending moisture in the walls is diverted downwards and away from the building.

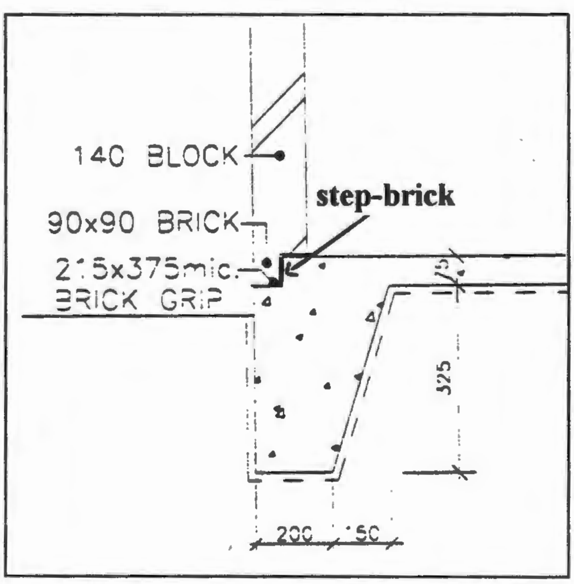


Figure 3 : The step brick in the foundations (Schreuder, 1999)

- **External coating**

The two options used presently for external coating in low cost housing projects are either a cement-based product, which is essentially limewash with cement (known as cemcrete), or acrylic paint. Two coats should be applied in both cases. There is controversy as to which product is more effective. Some argue that acrylic paints do not take to the alkalinity of the cement and tend to peel off the walls (Johnston, pers. comm., 1999). Others argue that the acrylic component of the acrylic paints do not allow the walls to breathe, which is an essential function of buildings. In this way, this paint tends to have the same effect as Gladwrap, and mould is encouraged to accumulate inside (Wight, pers. comm., 1999). Nonetheless, it was evident that cemcrete is being used less and acrylic paint more - the reason for this cited as the superior waterproofing properties of acrylic paint.

Neither of the two options are very effective. The walls still seem to drink in moisture when it rains, and some developments investigated were showing signs of new applications of the products being necessary. The external coatings were faded and had the appearance of being unevenly applied. Neither product would fulfil the durability criterion for technical sustainability, as the service life of both products is relatively short. Furthermore, neither product would fulfil the functional criterion of technical sustainability, as they are not successful in terms of damp-proofing the houses. Nor would either product fulfil the economically sustainable criterion of financial affordability for the beneficiaries, as there would be on-going maintenance costs, and extra costs would be required to alleviate the damp and cold (for example, through using more energy for space heating). Units would need to be repainted every 3 or 4 years (Molloy, pers. comm., 1999). Hence, no credits are awarded for the use of either product, but for more effective products such as skimplaster or plaster.

A site visit should be undertaken to establish whether or not credits should be awarded for the factors in this category.

4 credits for use of skimplaster or a similar product on all external walls, or
4 credits for the application of conventional plaster on at least the weather-facing external walls, or
6 credits for the application of conventional plaster on all external walls.

Skimplaster is a thick, external, cement-based coating which is thicker than paint, but thinner than plaster. It complies with the most severe requirements of the SABS 0400-1990 Part K Rainwater Penetration Tests. It is easy to apply, and is a dense, waterproof product which contains fibre-reinforcing. This ensures that there will be no shrinkage or cracking. This product forms a plaster-like layer of 3 to 5mm thick on the walls. It is far more effective than the cement-based or acrylic paints, but not as effective as plaster (Koch, pers. comm., 1999; Parish, pers. comm., 1999).

In Cape Town, most of the fierce, driving rain is associated with cold fronts and their prevailing strong north-westerly winds (Hurry *et al.*, 1981). Protection of the weather-facing wall would contribute significantly to reducing dampness of the houses.

For housing units to be truly waterproof, single leaf walls should be plastered. Plastering has the effect of achieving maximum moisture resistance of a wall. It provides a smooth surface which sheds water and helps to reduce the cracking of mortar in blockwork joints (Low, 1996). Maintenance and energy costs would be reduced considerably if plastering, which is a highly effective measure against water penetration, was implemented in low cost housing developments. The quality of life of the beneficiaries of these houses would be vastly improved if the housing units were plastered. Because plastering of houses would make make them truly waterproof, this factor is considered to have a high significance in terms of contributing to the overall sustainability of low cost housing projects.

- **Roofing and ceilings**

Due to cost constraints, the two options for low cost housing are metal sheeting or fibre cement roofing. The cost of these materials is similar. There are disadvantages associated with both materials. Metal sheeting contains no asbestos and it can be recycled. However, with both materials. Metal sheeting contains no asbestos and it can be recycled. However, this option would be more expensive due to the National Housing Board's regulation that a ceiling has to be installed with a metal sheet roof. Metal sheeting corrodes more quickly than fibre cement, especially near the coast. It is also often transported from Gauteng, which contributes to higher embodied energy values. Its insulative properties are also very poor (Johnston, pers. comm., 1999; Rendell, pers. comm., 1999).

The projects observed all used fibre cement roofing, which contains white asbestos. White asbestos (chrysotile) is apparently less harmful than brown (amosite) or blue (crocidolite – the most dangerous) asbestos (Henwood, pers. comm., 1999). Asbestos related diseases, such as asbestosis and forms of cancer, have been well researched and documented. Because of the known dangers of asbestos to human health, many countries - 12 in Europe alone - have banned the use or importation of any asbestos products (Kisting, N.D.).

There are two opposing schools of thought regarding the use of fibre cement in low cost housing. Some argue that there should be zero exposure to any type of asbestos, and that no level of exposure can be regarded as safe. Randeree (1998:4) notes that *"(e)ven exposure of short duration to a small quantity of asbestos fibres may lead to one of these fatal diseases".*

While fibre cement is a long lasting material, it will eventually deteriorate. Asbestos fibres will then become airborne, which is when they are dangerous – especially in a confined space such as a small housing unit (Kisting, N.D.). It is also argued that fibre cement is potentially dangerous as it cracks easily (Rendell, pers. comm., 1999). Residents of the Delft low cost housing project have complained about how easily this material breaks and cracks (Daniels, 1998). SABS has tested these roof sheets and claims that once the asbestos fibres are set in the cement, they are completely inert and therefore inactive (Daniels, 1998). In all of the housing projects observed, pre-cut asbestos sheets were used in the roofing, so no dust containing active asbestos particles would have been released on site during construction.

It is noteworthy that alternatives to fibre cement are being researched, and that alternatives to the asbestos component of fibre cement are being experimented with. The main susbtitutes are polyvinyl alcohol (PVA), aramid fibres and cellulose fibres (Harrison *et al.*, 1998). The Swiss Centre for Approriate Technology has undertaken extensive research into fibre cement roofing in developing countries. Stulz and Mukerji (1993) discuss substitution of asbestos with organic fibres, such as coir, hemp and wool.

No credits have been allocated for either option of roofing for this sustainability assessment model, as neither provide a viable option, in terms of sustainability. Fibre cement poses a threat to human health and therefore quality of human life. Steel involves extra costs as it corrodes easily, and ceilings need to be installed due to its poor insulative properties.

It should be established whether or not the factors in this sub-section are satisfied by means of undertaking a site visit.

<u>5 credits for installing ceilings.</u>

A ceiling has a marked impact on the insulative properties of houses. As warm air rises, it is trapped by the ceiling and warms up the dwelling. The heating needs of a house is reduced by 50% if a ceiling is installed. Moreover, ceilings reduce condensation. One human being emits, on average, up to 1 litre of moisture (perspiration) per day (Ward and Borchers, 1999). In small houses with many bodies and no ceiling, this has a negative effect on occupant health. Installing ceilings in low cost houses would contribute significantly to the overall sustainability of these projects. The quality of life of beneficiaries would improve and the cost of heating houses would be reduced. Installing ceilings in houses would have a highly significant effect in terms of contributing to the overall sustainability of low cost housing developments.

<u>2 credits for construction of dual-pitched roofs.</u>

A dual-pitched roof would allow for more ceiling space, which lends itself to higher insulative properties. A dual-pitched roof costs approximately R200 to R300 more per unit than the standard mono-pitched roof with a 5 degree slope (Malotane, pers. comm., 1999). Dual-pitched roofs are also aesthetically far more pleasing, and have a lower visual impact on the environment. Row upon row of units with mono-pitched roofs are not very attractive.

3 credits for roof overhangs of at least 400mm on the weather-facing side of the houses.
The blustery, strong, north-westerly winter wind in Cape Town causes turbulence, which drives winter rain horizontally and upwards. The upper regions of the weather-facing wall are especially susceptible to this driving rain. A 400 mm overhang reduces the effect of the rain by 60 % (Koch, pers. comm., 1999).

3 credits for roof overhangs on all four sides of the houses of at least 300 mm.
Overhangs of sufficient length ensure that water runoff from roofs will be diverted away from the houses (Wiseman, pers. comm., 1999).

1 credit for applying silicone or a similar sealant over the roof screws.
This ensures that the ingress of water through holes in the roof will be kept to a minimum (Malotane, pers. comm., 1999).

- **Paints and wood preservatives**

Green building practices discourage the use of paints and preservatives containing organic solvents. Organic solvents, commonly known as VOCs, are unstable at room temperature. They readily evaporate, leading to a process of 'off-gassing', and may cause poor indoor air quality. They are potentially dangerous to the environment and humans – especially paint factory workers and inhabitants of polluted buildings (Horn, 1998). Besides causing poor indoor quality, VOCs can also contribute to atmospheric pollution and photochemical smog (Woolley *et al.*, 1997). Formaldehyde is one of many examples of an off-gassing VOC. It is a known carcinogen and commonly found in building materials such as certain paints, chipboards and foamed products (Horn, 1998). Lead is also well known for its potentially harmful effect on humans, and is found in certain building materials. Its toxic effects on the human brain and blood have been well documented (Anink *et al.*, 1996).

Ecolabelling schemes overseas are giving serious attention to VOCs. In two of its ecolabelling schemes, the European Community specifies that VOCs in indoor paints should be roughly half of their current levels. In Canada, the Environmental Choice label is awarded to water-based paints, as opposed to oil-based paints which contain VOCs. Similarly, the Green Seal and Blue Angel ecolabel schemes in the USA and Germany also acknowledge the use of paints with low VOC content (Woolley *et al.*, 1997).

The paints and preservatives used in greenfields low cost housing developments are typically as follows:

- an external waterproof pure acrylic emulsion paint or a cement-based paint, and, in some cases, acrylic roof paint;
- a primer, undercoat and gloss enamel top-coat for the steel doorframes and windowframes;
- varnish and a wood preservative for the external doors and rafters (the rafters are treated with copper chrome arsenic (CCA) .

However, these paints and preservatives are not a major concern for this study, for the following reasons:

- Acrylic and cement paints have water, as opposed to oil, as the main solvent, and are applied only externally. The amount of organic solvents in acrylic paints is usually less than 10%. Typically, they contain only 2 – 7 % of organic solvents, compared with 40 – 50 % in alkyd paints (Anink *et al.*, 1996). Cemcrete is basically a cement-based limewash (Koch, pers. comm., 1999). The production of limewash comprises lime dissolved in water.
- Most varnishes are linseed oil based. Linseed oil is recommended as safe by the 'greenest' of builders. (Penman, pers. comm., 1999; Woolley *et al.*, 1997). While there may be a limited amount of solvent evaporation during application, this ceases once the varnish has dried (Penman, pers. comm. 1999).
- The primer used on the door and window frames of these low cost houses is zinc chromate. While there is some concern overseas that continued exposure to zinc chromate during the manufacturing process may be a contributing factor to cancer, this does not impact directly on occupants of these houses. Once again, once the paint is

dry, it poses little danger (Penman, pers. comm., 1999). The door and window frames come pre-painted, and are then usually covered by enamel and/or an undercoat on site.

- Primers, undercoats and enamels were traditionally oil-based. Nowdays they have an alkyd resin base, which does not pose any health problems (Penman, pers. comm., 1999).
- According to a major paint manufacturer and supplier to many of the low cost housing projects investigated (Plascon), none of their products contains any lead, formaldehyde or other toxic substances. The Plascon factory manufactures paints using no toxic susbstances, and is compliant with the International Organisation of Standardisation's (ISO) 9002 policy (Pritchard, pers. comm., 1999).
- The wooden doors and purlins are pretreated off-site. Any preservative, such as CCA which is most frequently used to treat the pine purlins, is applied at the manufacturers under a prescribed pressure process. The chemicals become fixed into the timber and subsequently no leaching can occur (Steers, pers. comm., 1999). Moreover, the purlins in the roof are far away from human contact. Varnish is applied over the preservative on the pre-treated doors.
- Paints containing lead are no longer sold on the South African market (Penman, pers. comm., 1999).
- None of the paints used in low cost housing mentioned above contain formaldehyde (Penman, pers. comm., 1999).

Due to the above-mentioned factors, there will be no significant impacts on occupant health. Indoor air quality is more likely to be affected by factors such as dampness, mould and ventilation than the paints and preservatives used. No credits have been allocated to this category, as there are no direct impacts on human health.

- **Frames for doors and windows**

Pressed steel door frames and steel clisco window frames (see Photograph 2) are typically used in project-linked, greenfields low cost housing developments. Clisco windows have become popular as the walls fit snugly into the frames of these windows, making leaking less likely (if the mortar is properly applied around the frame). Moreover, these windows are not more expensive than standard windows, and do not require lintels or window sills. They are also more difficult to vandalise (Malotane, pers. comm., 1999).

Photograph 2: A clisco steel frame window

The assessment of the factors in this sub-section can occur through reading of building specifications.

1 credit for installing galvanised steel door and window frames.

Ideally, the door and window frames should be galvanised. Galvanised steel has a longer life expectancy than ungalvanised steel, making these products more technically and economically sustainable. However, galvanised steel is more expensive than its ungalvanised counterpart.

1 credit for applying an undercoat and gloss enamel overcoat to door and window frames.

The door and window frames are pre-painted with a primer paint. Window and door frames should have at least a primer, a universal undercoat and a gloss enamel paint finish, in order to enhance durability. Two coats of gloss enamel is preferable (Pritchard, pers. comm., 1999).

1 credit for applying silicone or a similar sealant around the window frames.

1 credit for applying silicone or a similar sealant around the door frames.

Silicone is basically a plastic material, consisting of polymers (long chains of molecules), and is well-known for its impermeability. A silicone sealant applied around the frame of the windows and doors has the effect of reducing leaking and water penetration (Malotane, pers. comm., 1999; Koch, pers. comm., 1999).

- **Wood for doors and purlins**

Wood is utilised in project-linked housing units for roof purlins and external doors. There are, on average, two purlins per house. South African pine is typically used for purlins in the low cost housing. Pine or saligna (blue gum) is used for external doors.

2 credits for using saligna as opposed to pine external doors.

The quality of the external doors is important as they will be subjected to the elements. Saligna is a more stable wood than pine. It has stronger, more dense properties, which means that it will be less likely to move in response to moisture content than pine (Steers, pers. comm., 1999). This higher quality and durability is important in terms of long-term maintenance costs and weathering.

This factor can be assessed during a site visit or reading of written material.

- **Sanitary fittings**

The most commonly used material for plumbing and sanitary fittings in these houses, including the wash trough and pipes, is polyvinyl-chloride (PVC). There is currently a debate raging internationally between the chemicals industry and environmental campaigners. Campaigners are demanding an end to the production of PVC. Their main concern is the release of dioxins (toxic substances) during chlorine-based industrial processes. Dioxins can cause cancer, birth defects and damage to the immune system (Woolley *et al.*, 1997). Environmentalists' key objections are thus around the manufacture of PVC, rather than the use of it.

The PVC industry argues that its dioxin emissions are lower than alternative industries, such as metals produced by metal smelting. They also argue that PVC is a low energy plastic, and has proved to be safe and durable (Woolley *et al.*, 1997). For the purposes of low cost housing in South Africa, there is no viable alternative at present. At best, low cost housing contractors can endeavour to use manufacturers that have some form of environmental policy in operation (see section 3.4.5 of this chapter on biophysical issues). No credits are allocated for sanitary fittings in this assessment method.

ii) Quality Control

Quality control is of pivotal importance in attaining technical, and ultimately, socio-economic sustainability in low cost housing. As indicated earlier in this chapter, the application of certain technologies is required in order for certain socio-economic considerations to be met. Without adequate monitoring and inspection of the units as they are being constructed, this will not occur.

A high number of credits has been awarded for the criterion of adequate site supervision and quality control. The rationale behind this is that, without proper checks and balances in place, the technical sustainability (and ultimately, all areas of sustainability) of entire projects will be compromised.

1 credit for inspection of houses by municipal inspectors on a sample basis, or
2 credits for inspection of houses by municipal and contractor's inspectors on a sample basis, or
5 credits for inspection of houses by municipal and contractor's inspectors on an individual basis and at specified stages of construction.

The parties responsible for ensuring that satisfactory quality control is implemented are the building inspectors from the local and provincial authorities, and the developer or project manager. Contractors are accountable to the project manager for the quality of workmanship on site.

The local authorities in the Cape Metropolitan Area (CMA) follow similar strategies when inspecting low cost housing developments. Inspectors operate according to geographical areas, or projects allocated to them. During construction, units are usually inspected on a sample basis. On completion, and at the hand-over of units, inspectors are in charge of 'snagging' – a process whereby 'snags' in the unit are identified – with the beneficiary, project manager and inspector present. A certificate of delivery is signed by all (also known as the 'happy letter') and any defects are listed. These are repaired over the following 3 months. A 5% retention fee is withheld for a three month period by the local authority, during which the contractor is obliged to repair any defects. There is also a 12 month structural guarantee period for latent defects. The contractor is obliged to repair any structural defects within 12 months (Johnston, pers. comm., 1999; Madela, pers. comm., 1999; Wiseman, pers. comm., 1999; Wyngaard, pers. comm., 1999).

There are eight provincial low cost housing inspectors in the Western Cape, and a total of 200 projects. Provincial inspectors focus on the number of units delivered, as opposed to quality control. They are required to visit each project twice monthly and compile a basic monthly report, stating the number of units that have been completed and the number that are under construction. If there are serious, recurring defects in a development at the hand-over stage, the provincial inspector needs to notify the chief provincial inspector. Provincial inspectors have a minimal role in quality control in low cost housing other than this function (October, pers. comm, 1999).

The most important area for quality control rests in the contract between the local authority and the project manager / contractor. The building contractor plays a major role in day-to day quality control. Developers and project managers expressed concern that short-cuts were often taken by builders, thereby reducing the quality of buildings. The inspector from the local authority has an important function in terms of monitoring this. The ideal scenario for adequate quality control and site supervision would be to have a municipal inspector on site every day during construction. Over and above this, the building contractors or project managers should employ their own inspectors to be on site every day. The number of inspectors would vary according to the size of the project. There should be formal inspections (by municipal and contractor's inspectors) at specified stages of construction, as well as on-going, daily inspections of individual units (April, pers. comm., 1999; Wyngaard, pers. comm., 1999). This would contribute enormously to achieving sustainability in low cost housing projects.

Compliance with this factor is best assessed through interviewing building inspectors and project managers and perusing any relevant reports.

<u>*1 credit for complying with all sections of the National Building Regulations (NBR)*</u>

The NBR apply to all buildings, from low cost housing to luxury apartments. The regulations are very flexible. A qualified, competent person may approve a design as rational (defined by the NBR as a design which involves a process of calculation and reasoning), according to a set of 'deemed-to satisfy' rules. There are thus several ways of persuading a municipality that a particular design complies with the NBR (Dept of Housing, 1998). Although these standards are relatively low, they do provide some parameters for low cost housing.

The project manager or building specifications can be consulted in order to assess whether or not this factor is satisfied.

2 credits for using contractors who are registered with the National Home Builders Registration Council (NHBRC).

The NHBRC is a non-profit company which came into existence in 1995. Their function is to inspect the quality of buildings. Contractors who are registered with the NHBRC have a reputable standing. They run the risk of losing this status if, for example, they do not follow up on defects identified in the latent (12 month) and patent (3 month) periods. A law is being passed, whereby all building contractors involved in low cost housing have to be registered with the NHBRC as from January 2000. The provincial housing department will pay this body the necessary fee (1.4% of the total costs) to inspect low cost housing developments. This should increase quality control, as contractors who do not comply with stipulated requirements stand to be struck off the roll of the NHBRC (Johnston, pers. comm., 1999). However, many involved in low cost housing are sceptical as to whether or not quality control will improve on a practical level through the implementation of this law.

3.4.5 Biophysical factors

Table 8 below lists the biophysical factors of the sustainability assessment method, which have been divided into the sub-categories of energy efficiency, water efficiency and environmental investigations, policies and systems.

B. BIOPHYSICAL FACTORS (51 credits) **1. Energy Efficiency** ***(Maximum possible credits: 21)***
5 credits for as many housing units as possible facing in a northerly direction, or for houses facing in as northerly a direction as possible (but not deviating more than 15 degrees to either side of true north).
3 credits for north windows being equivalent to approximately 20% of the floor area.
3 credits for locating the rooms with the greatest need for heating on the northern side of the units.
1 credit for installing airbricks.
1 credit for the use of compact building forms, i.e square or round, as opposed to rectangular.
3 credits for designs consisting of semi-detached houses.
4 credits for designs consisting of fourplex houses.
1 credit for the installion of prepaid electricity meters in each house.

2. **Water efficiency** ***(Maximum possible credits: 15)***
5 credits for the installation of multi-flush toilet systems, **or**
4 credits for the installation of dual-flush toilet systems.
5 credits for installing cisterns with a flush capacity of 5 litres, **or**
4 credits for installing cisterns with a flush capacity of 6 litres.
1 credit for installing stopcock taps on water pipes (outside).
1 credit for installing stopcock taps near the cistern of the toilet.
3 credits for installing 'sit-in' baths or showers.
3. **Environmental investigations, policies and systems** ***(Maximum possible credits: 15)***
2 credits for input from an environmental specialist with regard to siting of project, **or**
4 credits for a scoping report, **or**
6 credits for a scoping report and an Environmental Impact Assessment (EIA) report.
5 credits for an Environmental Management Plan (EMP) or Environmental Contract being drawn up with the contractor.
2 credits for checking whether, and using, manufacturers and suppliers of building materials and products which have an environmental policy in place.
2 credits for checking whether, and using, manufacturers and suppliers of building materials and products which have an Environmental Management System (EMS) in place.

Table 8: Biophysical factors of the sustainability assessment method.

The maximum possible obtainable credits for biophysical factors is 51. A maximum of 21 and 15 credits is potentially obtainable for energy and water efficiency respectively, and 15 credits for environmental investigations, systems and policies.

i) Energy efficiency

The energy efficiency of low cost houses impacts on the biophysical and socio-economic components of sustainability. Energy consumption and efficiency has direct implications for the use of non-renewable resources globally, the level of pollutants in the atmosphere, and the quality of life of inhabitants of houses.

There is a complacent attitude towards energy efficiency amongst low cost housing developers (Department of Environmental Affairs and Tourism (DEAT) *et al.*, 1998). More often than not, low cost housing is not designed to take advantage of the local climate. This translates into houses being thermally inefficient, and cold during winter and hot in summer. This results in significant energy consumption and household expenditure in order to achieve minimum comfort levels (DEAT *et al.*, 1998). Many people in low income houses spend up to a quarter of their total income on household energy (Integrated Serviced Land Project (iSLP), 1999). Inefficient energy consumption in the form of electricity and other fossil fuels is unsustainable on a global level. Coal is a non-renewable resource, and reserves in South Africa will not last longer than approximately 100 years (Garman, pers. comm, 1999). Electricity generation is a major cause of air pollution and contributes to the build up of carbon dioxide in our atmosphere.

The Department of Housing has recognised the urgency of incorporating sustainable energy principles into the design of low cost housing. Together with the Department of Minerals and Energy, they have commissioned the Energy and Development Group to work on policy relating to energy issues in low cost housing (Ward and Borchers, 1999).

The benefits of energy conscious design are significant, and benefit the individual, the nation and the natural environment. Home occupants experience cost savings, improved indoor air quality and comfort (as burning fuels indoors will be minimised) and natural lighting. On a countrywide level, there will be a lower demand for electricity, and health services (due to decreased respiratory illnesses and burn injuries caused by household fuels). The environmental benefits, as mentioned earlier, will be decreased pollution levels and lower levels of use of non-renewable resources (Ward and Borchers, 1999).

The energy supply for low cost housing should be clean, safe and affordable (Sowman and Urquhart, 1998). Electricity fulfils these criteria most aptly - if designers and users operate according to thermally efficient principles. The cost of linking up with the national grid is relatively cheap. Other alternatives, such as solar energy and gas, should continue to be researched, but for the purposes of this research, are not yet considered to fulfil the requirements of Best Available Technology not Entailing Excessive Cost (BATNEEC).

In project-linked schemes, each house is supplied with a 20 amp readyboard which consists of a prepaid meter, a socket and a bulb. None of these houses have hot water or a geyser. Energy in these homes is utilised for lighting, heating (the home and water), cooking, and sometimes, refrigeration and media appliances. In all of these instances, electricity is deemed to be the 'best' option (Ward and Borcher, 1999). Most urban low income households use a combination of electricity and fuels (paraffin, coal or gas). Paraffin is used extensively, even though it costs more than electricity. Paraffin stoves are cheaper to purchase than electric stoves. Paraffin is also sold in almost every small store, and is therefore easily accessible. Moreover, it can be utilised for space heating and cooking.

What is of relevance to this study is the question of designing thermally efficient low cost houses. The National Norms and Standards document states that, *"affordable housing must take cognisance of the need for the resultant dwellings to be thermally efficient"* (Department of Housing, 1998:10). This involves implementing basic principles of passive thermal design. Basically, houses designed according to these principles should have north facing windows, insulated ceilings and insulated walls, or walls with materials which retain heat. In this way, the heating expenditure of these houses would be decreased by 75% (Ward and Borchers, 1999). Inhabitants would spend less on energy for heating and lower demands would be made on the national electricity grid.

All of the factors in this sub-section can be best assessed by means of a site visit.

5 credits for as many housing units as possible facing in a northerly direction, or for houses facing in as northerly a direction as possible (but not deviating more than 15 degrees to either side of true north).

The orientation of houses (and their windows) in relation to the sun is of prime importance. This is a basic principle of passive thermal design. Good building orientation will enhance solar input into the dwellings, making them thermally efficient and habitable. Designing homes which are north-facing (with north-facing windows) will maximise the harnessing of the energy of the sun for heating and lighting (Holm, 1998). If low cost housing projects are designed according to this principle, the overall sustainability of these projects will be greatly enhanced. Hence, this factor has been allocated a high number of credits.

3 credits for north windows being equivalent to approximately 20% of floor area.

The NBR stipulates that the windows of a house should be at least 10% of the floor area. The norms and standards stipulated by the Department of Housing states that the minimum window area for habitable rooms should be 5% of the floor area. However, according to principles of passive thermal design, the optimum percentage is 20% of the floor area for north windows. When solar radiation strikes glass, part of the heat is reflected, part is absorbed and the remainder is directly transmitted. The absorbed radiation is re-emitted to the inside and outside of the building through long-wave radiation. Once inside, the radiation can be absorbed by the floor. Twenty percent of the total floor area is the optimum size glazed area on the north side of a dwelling for 'solar collection' to produce maximum thermal efficiency (Holm, 1998).

3 credits for locating the rooms with the greatest need for heating on the northern side of the units.

Those rooms where people spend most of their waking hours should be on the warmer side of the house, with service rooms placed on the south side to act as a thermal buffer (DEAT *et al.*, 1998; Holm, 1998). Low cost houses are usually one-roomed with a bath-room, so this room, as opposed to the bathroom, should be on the northern side of the house.

1 credit for installing airbricks.

Adequate ventilation and air circulation is a basic principle of thermal efficiency. It impacts directly on the quality of indoor air, which in turn influences the health of occupants. Houses that are not well-ventilated exacerbate discomfort and ill-health. There is some disagreement as to how effective the installation of airbricks is. Some believe that airbricks are important in low cost houses on the Cape Flats, as people tend to keep their windows shut in summer as sand gets blown into the houses. In winter, they may keep them shut to keep out cold winds (Schreuder, pers. comm, 1999). Others argue that inhabitants usually block the airbricks up to stop sand from blowing into the houses (Wight, pers. comm., 1999). It may be prudent practice to install them anyway and to let the people do what they will with the airbricks (Hopkins, pers. comm., 1999).

Condensation is also a major hazard in these houses. Lack of air circulation and ceilings contributes to this. Indoor air pollution and dampness are intensified by the burning of fuels such as paraffin, gas and coal inside the house. The occupants of low cost houses frequently use these fuels, especially paraffin, for cooking and space heating. Paraffin is more expensive than electricity, but more 'accessible'. A bottle of paraffin costs R2 from a local store, whereas the minimum amount of electricity that can be bought on a prepayment card is R5, and is only available from certain stores.

While gas and paraffin are less polluting than wood and coal, they tend to increase dampness and condensation. Burning paraffin increases the water vapour content in the atmosphere, due to its hydrocarbon properties (Molloy, pers. comm., 1999). Burning fuels indoors has a direct bearing on health, and can cause respiratory disease. Two hundred and seventy times more children die from respiratory disease in South Africa than in Western Europe (Sowman and Urquhart, 1998). Respiratory disease caused by smoke indoors is the second-highest cause of infant mortality in our country (Ward and Borcher, 1999).

1 credit for the use of compact building forms, i.e square or round, as opposed to rectangular.

In studying the energy efficiency of buildings, Holm (1998) discovered that the shape of houses is important in terms of energy efficiency. He states that a square or round unit is more energy efficient than a narrower one, as a low surface to volume ratio reduces the exposed area of envelope to the environment.

3 credits for designs consisting of semi-detatched houses.

4 credits for designs consisting of fourplex houses.

When units share walls, they provide more insulation against heat loss in winter than when they are free-standing, as there are fewer exposed walls from which to lose heat. A free-standing house is energy inefficient as the heat which is absorbed and stored during the day is lost through four walls at night (DEAT *et al.*, 1998; Sowman and Urquhart, 1998). Fourplex units are more energy efficient than semi-detatched units, as more houses will share more walls. Besides conserving energy, this is sustainable in that it saves on materials and costs of services.

While the thermal capacity of building materials is relevant in considering thermal efficiency of buildings, it is not appropriate to award credits for the use of such materials in the greenfields projects under investigation. Cement blocks and concrete floors are used almost exclusively as they are the cheapest and most accessible building materials. It so happens that cement and concrete have relatively high heat storage capacities. They have the ability to store heat for a prolonged period and release it slowly. Heat which has accumulated in cement block walls (of approximately 250mm thickness) during the day takes about 7 hours to be released into a building and the surrounding atmosphere at night (Holm, 1998).

1 credit for the installation of prepaid electricity meters in each house

It is the policy of local authorities and Eskom to install prepaid electricity meters in low cost houses. The rationale behind this is that these institutions save substantially on administrative costs, and that problems with credit are alleviated (Garman, pers. comm., 1999). Prepaid meters also encourage users to utilise electricity more efficiently. Consumers can relate the number of electricity units utilised to the amount paid for the units, which is likely to encourage more efficient energy consumption.

ii) Water efficiency

Water is a critically scarce and valuable natural resource that should be utilised as sparingly as possible. As with energy efficiency, designing and building for efficient water use in low cost housing has a direct bearing on biophysical and socio-economic factors of sustainability. Efficient use of water means this natural resource will be preserved and protected, and that occupants of houses will have lower water bills to pay, leaving more of their diposable income for other important needs.

The main issues around water use in South Africa, and the Western Cape, are about scarcity, unequal access and pollution of water courses. Those living in greenfields projects now have access to water, through the provision of water services in the form of piped, potable water. It is a cause for concern that the construction of these houses could cause pollution and damage to nearby water bodies, primarily through run-off which may contain building rubble and materials. The seriousness of this environmental impact cannot be overemphasised (see part (iii) of this section).

South Africa's climatic zones vary from semi-arid to hyper-arid (Davies and Day, 1998). While the Western Cape does have an annual rainfall higher than that of the national average of 452 mm per year, there is still a critical water shortage in the Western Cape, primarily due to the very short run-off distances of watercourses to the sea. This is exacerbated by a burgeoning population and the pollution of water resources.

While it is true that low-income households utilise far less water than more privileged households, the cumulative impacts of water consumption of thousands of low-income homes cannot be overlooked.

Every housing unit in a greenfields project is fitted with one toilet (usually with a 9 litre cistern), a wash trough and at least a place in the bathroom to install a bath. One of the developments investigated had small, shallow 'sit-baths', measuring approximately 1 metre by 1 metre with a depth of about 30 cm. The communities in these developments apparently prefer the option of baths to showers, as these can double-up as containers to do washing (April, pers. comm.1999; Malotane, pers. comm., 1999). However, very few occupants have actually installed baths, due to the expense involved. As mentioned earlier, there are no geysers. Hot water would be obtained by heating it on stoves.

The flushing of toilets accounts for the highest water usage in all houses. Camp (N.D.: 46) writes that the toilet is "*the biggest guzzler of indoor water*." Certain water conservation measures could be employed in the design phase of these projects to ensure that water is used efficiently.

The best means of assessing the factors relating to water efficiency would be to undertake a site visit.

5 credits for the installation of multi-flush toilet systems, or
4 credits for the installation of dual-flush toilet systems.

Flusing systems which utilise less water than the conventional flush system would have a highly significant effect on the sustainable use of water in low cost housing projects. A dual-flush system gives one the option between a small flush, of about 3 litres, for liquid waste, and a larger flush, of about 7 litres, for solid waste (Davies and Day, 1998). It saves up to 50% of the amount of water used for the normal flush method, if the low flush is used most of the time (Taylor, pers. comm., 1999). A multi-flush system saves 59% of the amount of water used for normal flushing. It costs R10 to R15 more per toilet to install than a conventional, traditional system. The flush mechanism is controlled by human action pushing the toilet handle, so that only as much water is used as is needed for each flush (Taylor, pers. comm., 1999). This is the most economical flush mechanism for toilets in terms of water-saving.

5 credits for installing cisterns with a flush capacity of 5 litres, or
4 credits for installing cisterns with a flush capacity of 6 litres.

Cisterns with smaller flushing capacities would have a highly significant effect on water consumption in low cost housing. The smallest available cistern in South Africa is 5 litres. These were used in the Marconi Beam housing development. In Britain the smallest cistern has a flush capacity of 3.5 litres (Rendell, pers. comm., 1999).

Homes in greenfields projects usually house a number of people. The toilet is bound to be flushed many times a day. With an average of 10 flushes a day at 9 litres per flush (for a 9 litre cistern), 90 litres of water could easily be used per house per day for toilet flushing. A 5 litre cistern would utilise only 50 litres, translating into a 40 litre saving per unit per day. Multiplied by the thousands of low cost housing units on the Cape Flats alone, this translates into a significant saving of water. This would have the added advantage of saving on water costs for occupants. Alternative flush systems and smaller cisterns are undoubtedly the more sustainable options.

1 credit for installing stopcock taps on the water pipes (outside).

One leaking tap, at only 50 drops per minute, wastes at least 5 litres of water per day (Davies and Day, 1998). A larger leak will waste more water, and leaks in many houses even more so. A stopcock allows residents of the houses to have some control over this, preventing water wastage and high water bills.

1 credit for installing stopcock taps near the cistern of the toilet.

Cisterns often leak, but not always noticeably. In the United States, it is known that one in every four toilets leaks. Camp (N.D.) notes that the toilet is one of the biggest sources of leaks in the home, but these leaks are often difficult to detect. This can be checked by placing a piece of toilet paper on the back of the pan. If it becomes sodden after two minutes, the cistern is leaking (Davies and Day, 1998). A stopcock near the cistern will assist with saving water and water costs, and give occupants some control over their water consumption as they can switch off the water supply to the toilet if there is a leak (Malotane, pers. comm., 1999).

Other water-saving devices, such as tap aerators, are not included in this assessment system. It is possible that they may be removed. Moreover, these devices probably would not save much water, as people might still fill wash troughs to a certain level (Taylor, pers. comm., 1999) .

3 credits for installing 'sit-in' baths or showers.

Showers and 'sit-in' baths are more water efficient than the conventional bath. An average bath of 100mm depth of water uses 60 litres of water, whereas a 4 to 5 minute shower uses less than 30 litres of water (Camp, N.D.). The 'sit-in' bath is deemed by some to be the best option for low cost houses. Due to their small size, they do not use more water than a shower of approximately 5 minutes. Moreover, two people can sit comfortably in the bath together. As mentioned earlier, these baths also have multi-purpose functions, such as being used for washing clothes. An added advantage is that water can be heated for these baths. Showers with shower trays cannot be considered for the low cost housing market at this stage. These are expensive and are targeted for higher income groups (Taylor, pers. comm., 1999).

There is on-going debate regarding rainwater harvesting, and whether rainwater tanks should be installed in low cost houses in the Western Cape. This could be problematic as these houses have no guttering. Also, due to the winter rainfall, the question arises as to how much water would actually be saved. There is also the expense involved in installing these tanks (Rendell, pers. comm., 1999). The option of rainwater harvesting in a shared core area with larger, communal basins for washing of clothes needs to be researched (Wight, pers. comm., 1999). For the purposes of this study, credits were not awarded for rainwater tanks as the facts remain inconclusive.

Biophysical principles of sustainable development and construction include the reducing of the use of all natural resources. As is evident from sections (i) and (ii) above, environmental degradation frequently occurs due to the overconsumption of resources, such as water and energy. Natural resources should be protected and conserved at all costs.

iii) Environmental investigations, policies and systems

The minimising of damage to sensitive natural environments is an important biophysical principle in the achievement of sustainablility in construction and development. Siting of low cost housing developments is important, in terms of the impacts of these projects on sensitive natural environments, on a regional and local scale. Undertaking environmental investigations and implementing sound environmental systems and policies will contribute to attaining biophysical sustainability. The fact that greenfields housing developments consist of unitary houses makes them very flexible and adaptable to almost any site. These projects can be built relatively easily in different environments, without taking the potential environmental impacts into account (World Bank, 1992). This can be detrimental to sensitive natural environments as the effects on the biophysical environment may be easily overlooked or disregarded. Comprehensive environmental investigations are necessary in order to ensure that biophysical impacts are taken into account in housing projects.

The best way of minimising environmental impacts of low cost housing developments is to avoid ecologically sensitive areas altogether. A regional database identifying and mapping environmental resources would assist in applying sound principles of biophysical sustainability to site selection for low cost housing developments.

The Cape Metropolitan Council (CMC) is developing a Geographical Information Systems database, which maps regional environmental resources including wetlands, forests, important natural habitats, major drainage patterns, prime agricultural land and geotechnical information. The CMC is also in the process of adopting policies under the Metropolitan Spatial Development Framework which offer protection of certain areas of the CMA from development, such as those declared as areas for public open space under the Metropolitan Open Space System and areas which fall beyond the delineated urban edge of the CMA. This database and information is valuable for the strategic planning of housing developments, and should be utilised by all of those involved in low cost housing developments.

The World Bank has published useful sectoral guidelines for the mangement of low cost housing developments and the environmental impacts thereof, in terms of siting of projects and environmental impacts on sites. There is growing concern worldwide about the major and severe impacts housing projects may have on the natural environment, on a regional and site scale. Housing projects can consume considerable amounts of land. Regional impacts may involve the loss of scarce and valuable land, such as prime agriculutural land, and the loss of wetlands or habitats of rare or endangered species (World Bank, 1992).

Site impacts are usually related to construction activities. The building of low cost housing projects is often a disorderly and rapid process, with the emphasis being on completing the project rather than protecting the environment. Soil is exposed as vegetation is removed. This was evident in Ocean View, where excess run-off occurred and valuable topsoil was lost and blocked up stormwater drains (Sowman and Urquhart, 1998). Grading and excavation exacerbate this condition and heighten the potential for erosion and siltation. Soils are compacted by heavy machinery, rendering them less permeable and increasing the likelihood of flooding. Natural drainage systems are disrupted and surface and groundwater quality may be affected by run-off containing toxic substances, or dumping in waterbodies. Groundwater quantity may also be effected due to an increase in the impervious area of the site (World Bank, 1992). A summary of the World Bank's (1992) guidelines for low cost housing regarding siting and the management of potential environmental impacts of these housing developments is presented in Table 9.

CHECKLIST FOR POTENTIAL NEGATIVE IMPACTS	SUGGESTED MITIGATING MEASURES
1) Displacement of existing land uses.	⇒ Consider trade-offs between land uses and values for housing and other uses carefully.
2) Degradation of environmentally sensitive areas.	⇒ Ensure that environmentally sensitive sites are identified and not threatened by project location.
3) Danger to residents:	
a) through hazardous natural conditions;	⇒ Ensure site is not located in a major floodplain, areas of unstable soil conditions or coastal zone inundation areas, and design accordingly if site cannot be moved.
b) from human-made conditions;	⇒ Identify landfill areas and areas used for dumping of toxic wastes. ⇒ Investigate alternative sites.
c) from other adjacent land-uses.	⇒ Ensure site is located away from noise and pollution sources. ⇒ Investigate alternative sites.
4) Destruction of historic or cultural resources.	⇒ Make provision for significant areas to be set aside in specifically zoned areas. ⇒ Consider alternative sites.
5) Damage to sites and surroundings due to disruption of natural systems.	⇒ Identify natural systems of the area and protect with open spaces and buffer areas. ⇒ Adapt layouts to fit natural systems.
6) Degradation of natural habitats caused by fragmentation.	⇒ Connect natural site features with open space systems. ⇒ Protect natural habitat from destructive practices during construction.
7) Increased erosion and siltation due to increased run-off from developed sites.	⇒ Preserve natural drainage patterns and existing vegetation. ⇒ Design a stormwater management programme which includes minimising impervious area and uses natural vegetated swales instead of pipes.
8) Depletion and/or pollution of local groundwater resources.	⇒ Ensure projected use of groundwater is within regenerating capacity of the natural system. ⇒ Prevent pollutants and rubble from entering water bodies.
9) Degradation of soil from erosion, removal or compaction.	⇒ During construction implement erosion control plans.
10) Loss or degradation of natural vegetation.	⇒ Identify important stands of vegetation and incorporate these into design layout or open space system. ⇒ Protect these areas during construction through temporary fencing or marking.

Table 9: Summary of World Bank's guidelines for environmental management of low cost housing developments (after World Bank, 1992).

Comprehensive environmental investigations are required to ensure that biophysical principles are upheld when considering siting and environmental impacts on sites for low cost housing projects. The guidelines which are summarised in Table 9 would assist environmental practitioners in local authorities and others involved in the low cost housing sector in the undertaking of such environmental investigations.

2 credits for input from an environmental specialist with regard to siting of project, or
4 credits for a scoping report, or
6 credits for a scoping report and an Environmental Impact Assessment (EIA) report.

As indicated in section 2.2.2, environmental practitioners in South Africa have been involved in executing EIAs since the early 1970s. The focus of these EIAs has been on siting and the avoidance of development in sensitive environments, as well as management plans for the protection of the natural environment during the implementation of projects (Hill *et al.*, 1999).

EIAs are valuable tools when considering the siting of low cost housing developments and their environmental impacts. There are certain instances where an EIA, or at least a scoping report, will automatically be required for low cost housing developments. Under the EIA Regulations, which were promulgated in September 1997, a change of land use where land was not previously zoned for residential use to residential development requires an EIA (this includes, for example, a change in land use which is zoned for agriculture or open space to any other land use). Over and above this, if a proposed site is regarded as environmentally sensitive, the municipal authority for the area will undertake an initial environmental investigation. It is the policy of the environmental departments of the local authorities in the CMA to liaise closely with their housing and planning departments, as well as with Cape Nature Conservation and NGOs. In this way, they are able to effectively monitor proposals for low cost housing developments and to undertake environmental investigations as and when appropriate (Callaghan, pers. comm., 1999).

Environmental assessments require a broad knowledge of environmental impacts at different scales. It is important for the environmental impacts of low cost housing developments to be investigated in every project. While a developer may feel their project has no significant environmental impacts, it is quite possible to overlook these without the input of an environmental specialist. A developer may overlook a seasonal wetland, for example, and build houses on it. The cumulative impacts of all of the low cost housing projects on the biophysical environment of the Western Cape region are substantial, and environmental investigations would assist in mitigating these impacts. Undertaking EIAs has a highly significant impact on the attainment of biophysical sustainabililty in a low cost housing projects.

The project manager should be asked whether any environmental investigations were undertaken and relevant reports should be perused.

5 credits for an Environmental Management Plan (EMP) or Environmental Contract being drawn up with the contractor.

As indicated, sensitive environments are vulnerable to building impacts and disturbances, especially where the emphasis is on completing the project. An EMP or Environmental Contract contribute a greatly to achieving biophysical sustainability in a low cost housing project. Such a plan or contract should describe the proposed implementation of the project, the controls and conditions over the implementation to ensure that environmental impacts are monitored and mitigated and how environmental restoration will be carried out after construction (DEAT, 1992). Ideally, such a plan should be drawn up at the earliest possible stage of the project. It is important that the EMP or Environmental Contract is designed to continue throughout the entire project cycle, including the rehabilitation of the environment once building has been completed. Integrating environmental awareness into the design of the project will inevitably reduce the need for costly mitigation measures.

The project manager / contractor should be asked whether an EMP or environmental contract were drawn up and these documents should be perused.

2 credits for checking whether, and using, manufacturers and suppliers of building materials and products which have an environmental policy in place.

2 credits for checking whether, and using, manufacturers and suppliers of building materials and products which have an Environmental Management System (EMS) in place.

The extraction and manufacture of materials for building purposes affects the natural environment. When raw materials are extracted from the earth, natural resources are depleted, often at a rate which is faster than the time taken for them to regenerate in the earth. Poor manufacturing practices and policies of industries, such as releasing untreated effluent into waterbodies and burning toxic materials, can exacerbate water and air pollution. The health of workers can be threatened if the levels of their exposure to dangerous or toxic elements, such as asbestos or zinc chromate, is not monitored.

Contractors and developers can make a contribution to the protection of the biophysical environment by supporting suppliers and manufacturers who have adopted and are implementing environmental policies and systems. This is commensurate with a principle of economic sustainability, whereby Hill and Bowen (1997) state that environmentally responsible suppliers should be utilised.

A company or manufacturer who has an EMS in place displays a commitment to principles of sustainable development. An EMS is a proactive approach whereby effective environmental management is implemented in the industry to ensure that there are minimal adverse environmental impacts.

The project manager and / or contractor should be asked whether they have a policy of using suppliers and manufacturers of building products who have environmental policies or systems in place. The suppliers and manufacturers themselves can be contacted for further details regarding their environmental policies and systems.

3.4.6 Socio-economic factors

Table 10 below lists the social and economic factors that are regarded as important in the attainment of socio-economic sustainability in this study.

C. SOCIO-ECONOMIC FACTORS (22 credits) ***(Maximum possible credits: 22)***
2 credits for at least one 1-hour meeting with the community covering basic issues relating to sustainable living practices, **or**
3 credits for at least two 1-hour meetings with the community covering issues relating to sustainable living practices, **or**
6 credits for 3 or more 1-hour education and training workshops for beneficiaries covering issues relating to sustainable living practices.
3 credits for employing emerging contractors from within the community.
3 credits for implementing innovative ideas around waste and job creation.
2 credits for houses being easily extendable.
2 credits for a show house/s being constructed with accessible information available regarding the units.
6 credits for holding quarterly meetings with the community subsequent to their occupation of the houses, for the first year after handover.

Table 10: Socio-economic factors of the sustainability assessment method.

The maximum possible credits obtainable for socio-economic issues of sustainability in this study is 22. Most of these credits relate to the education and training of beneficiaries, which is considered of primary importance in terms of achieving and maintaining the social and economic sustainability of greenfields low cost housing developments.

The scope of social and economic issues, or socio-economic issues, relating to sustainability in low cost housing, is considerable. Every principle of social and economic sustainability in Hill and Bowen's (1997) four pillars of sustainable construction in itself justifies an individual study. A few of these have been focused on, which are believed to be relevant to this particular study. The fact that important issues such as the public participation processes involved in each project have not been the focus of this study does not mean they are any less important (see section 3.3). Taylor (cited in Dagliesh *et al.,* 1997) argues that social processes and participation have been provided for and undertaken in the new South Africa, especially in the arena of low cost housing. The EIA regulations referred to in section 3.4.5 also make adequate provision for public participation. The aim of these regulations is to ensure that the public is involved with decisions regarding, and the undertaking of, activities listed in the regulations. The final draft of the National Housing Code, which summarises all policies and legislation regarding low cost housing to date, supports people-centered development, where the *"housing process is driven by the people of South Africa"* (Dept. of Housing, 1999: 7UF).

Most of the factors below would be best assessed through interviewing the project manager and reading relevant documentation. The two factors relating to the construction of show houses and the extendability of houses might be best evaluated through a site visit.

2 credits for at least one 1-hour meeting with the community covering basic issues relating to sustainable living practices, or
3 credits for at least two 1-hour meetings with the community covering issues relating to sustainable living practices, or
6 credits for 3 or more 1-hour education and training workshops for beneficiaries covering issues relating to sustainable living practices.
In order to ensure that socio-economic issues of sustainability are addressed in housing projects, education and training of beneficiaries is crucial. This would make a highly significant contribution to the long-term sustainability of low cost housing projects.

As indicated in section 3.4.4, with all project-linked greenfields developments, there is a handover date where beneficiaries are given the keys to their new house and an inspection is undertaken. The designated inspector is usually from a local authority. Part of this process includes the signing of the so-called 'happy letter', whereby the beneficiary and the inspector sign to indicate whether they are happy with the unit and whether there are any defects.

The 'happy letter' is an opportunity for basic education. It could contain tips on water and energy efficiency, gardening, or on basic building techniques, such as installing a ceiling or maintaining foundations when wind blows away the sand – which happens frequently on the Cape Flats (Hopkins, pers. comm., 1999).

Wherever possible, workshops should be conducted with potential beneficiaries. As the time draws nearer for people to take occupation of their units, they could be invited to workshops, which might cover a range of issues, as mentioned above.

3 credits for employing emerging contractors from within the community.

Employing people from the local community will enhance the economic sustainability of the project as employment opportunities will be created for the local community. Previously disadvantaged contractors have, through enforced limitations, been unable to acquire the experience that other contractors have. This practice will also enhance the social sustainability of the project, as persons from within the community will acquire new skills which can be utilised and shared within the community after construction has been completed.

3 credits for implementing innovative ideas around waste and job creation.

Waste issues are significant in low cost housing developments, and are relevant to socio-economic and biophysical aspects of sustainability. Employment opportunities can be created, communities can become cleaner through creating litter-free areas and the natural environment can be spared excess pollution and degradation. Innovative ideas to enhance this can be encouraged. The City of Cape Town has launched the "Masicoe Project" (Let's Clean Up) in certain low-income areas. These areas are divided into zones, with one person living in each zone being hired as a contractor to the City of Cape Town. His/ her duty is to deliver plastic bags to every home and collect them weekly. These bags are stored in containers which are removed by the Cleansing Branch. The contractor is also responsible for ensuring that his/her area is free of litter (iSLP, 1999). This project has the dual function of creating employment for members of the community, as well as having an educational and awareness function.

Blaauwberg Municipality in Cape Town has launched a similar initiative in a greenfields low cost housing project. Persons living in the project area are employed by the

Municipality as refuse removal contractors. The community are actively involved in selecting these persons. The emphasis is on establishing a partnership between local government and the community, and job creation. This scheme hopes to look at methods of incorporating recycling in the future (Madela, pers. comm., 1999).

Greyling (1998) describes a similar project in a low income housing development in Krugersdorp. This scheme goes one step further, in that the waste manager not only collects garbage and brings it to a garbage depot, but also sorts the garbage into wet-stuff (used for making compost), recyclable metal, glass and paper. Recycling companies provide containers for these materials, and collect them every two weeks. This scheme provides job creation and encourages recycling of materials.

2 credits for houses being easily extendable

This usually involves installing a lintel above a potential doorway, where the blocks beneath the lintel can easily be knocked out by the occupants of the house, in order to build on another room. Alternatively, other considerations should be incorporated, such as the siting of the units on the plots so that extensions to the houses can easily be accommodated on the plot. This concept supports social aspects of sustainability. People will be able to individualise and humanise their houses. Having 6 or 10 people living in one room can lead to a myriad of social problems. Moreover, adding another room can be income-generating in the form of creating space for a small business or renting out the extra space.

2 credits for a show house/s being constructed with accessible information available regarding the units.

One show house per option available in the project should be constructed. This contributes to a sense of empowerment for individuals as information and queries can be exchanged before people move into their units. Where options are available, this enables individuals to make an informed choice. A person/s from the contracting company should be available at all times to supply information to potential beneficiaries. This is an excellent opportunity for informal education around issues of sustainability, for example the advantages of choosing a semi-detached unit, urban greening and vegetable growing.

6 credits for holding quarterly meetings with the community subsequent to their occupation of the houses for the first year after handover.

This service would serve an ongoing educational and supportive function. The process of development needs to be taken through its full cycle in order to be truly sustainable. If there is no adequate follow-up for an adequate time period, to ensure that the quality of units was acceptable, the maintenance of units was affordable to occupants and that their health was not been affected negatively by poor living conditions, principles of social and economic sustainability would be neglected. A follow-up system would make a highly significant contribution to the long-term sustainability of low cost housing projects.

The way in which the sustainability assessment method for cement block, greenfields low cost housing on the Cape Flats has been developed has been explained in this chapter. The rationale behind the selection of certain categories and their weighting, the selection of certain factors and the allocation and awarding of credits thereto has been explained. The next step in the process was the pilot application of the sustainability assessment method in order to demonstrate it and to ascertain whether or not it is a feasible method for assessing sustainability in cement block low cost housing on the Cape Flats.

Chapter 4

4. APPLICATION OF THE SUSTAINABILITY ASSESSMENT METHOD

The aim of this chapter is to demonstrate the pilot application of the sustainability assessment method using two case studies. The results of this application are analysed and discussed.

4.1 Selection of case studies

Two case studies were chosen from the seven which were investigated. One was situated in the jurisdiction of the Tygerberg Municipality and the other in the area of the Oostenberg Municipality. Both projects consisted of greenfields, cement block houses which were at various stages of construction. When completed, the former project would consist of approximately 300 units and the latter, approximately 3 500 units.

BREEAM states that *"(t)he assessment, which is carried out at the design stage, is based on readily available and generally accepted information"* (Prior, 1993:2). The assessment in this dissertation was carried out subsequent to the initial design stage, and utilised readily available and generally accepted information. The basis for the selection of these two case studies (besides the fact that they are project-linked, greenfields low cost housing developments which are situated on the Cape Flats) was the availability and accessibility of information, obtained from building specifications and plans and other relevant reports, site visits and ongoing consultations with the developers, project managers and local authorities.

4.2 Results and discussion of application of sustainability assessment method

Table 11 indicates the scores obtained as a result of the application of the assessment method to the two case studies (case study A and case study B). The awarding of credits was done by the researcher, according to the available information and site visits.

CATEGORIES, SUB-CATEGORIES AND FACTORS	CASE STUDIES	
A. TECHNICAL FACTORS (67 credits) **1. Building Materials and Methods** ***(Maximum possible credits: 59)***	**A**	**B**
• **Cement blocks** ***(Maximum possible credits: 9)***		
3 credits for the use of cement blocks which have a strength of at least 3.5 Mega Pascals (MPa).	3	3
3 credits for the use of cement blocks with a high moisture resistance.	3	3
1 credit each for cement sill blocks, precast concrete thresholds, and/or weatherbars installed at the front doors.	2	1
Total for cement blocks:	**8**	**7**
• **Mortar mix and application** ***(Maximum possible credits: 18)***		
3 credits for the use of mortar with a mix of cement:lime:sand in a 1:1:6 ratio.	0	0
3 credits for the addition of a moisture inhibitor to the mortar.	0	0
3 credits for the use of the pointing method to finish off the mortar joints properly.	0	3
3 credits for the use of the bagging method to finish off the mortar joints and application properly.	3	0
3 credits for applying and passing the Minimum Agrement Norms and Technical Advisory Guide (MANTAG) test for moisture penetration to the north-facing wall.	0	0
3 credits for allowing houses to dry out sufficiently before occupation.	0	0
Total for mortar mix and application:	**3**	**3**
• **Foundations and damp-proof coursing (DPC)** ***(Maximum possible credits: 6)***		
2 credits for the use of DPC which is at least 250 microns thick.	2	2
2 credits for DPC which is at least 150mm above the level of the surrounding ground.	2	2
2 credits for the use of a step brick in the foundations.	2	0
Total for foundations and damp-proof coursing:	**6**	**4**
• **External coating** ***(Maximum possible credits: 6)***		
4 credits for use of skimplaster or a similar product on all external walls, **or**	0	0
4 credits for the application of conventional plaster on at least the weather-facing external walls, **or**	0	0
6 credits for the application of conventional plaster on all external walls.	0	0
Total for external coating:	**0**	**0**
• **Roofing and ceilings** ***(Maximum possible credits: 14)***		
5 credits for installing ceilings.	0	0
2 credits for construction of dual-pitched roofs.	2	0
3 credits for roof overhangs of at least 400mm on the weather-facing side of the houses.	0	0
3 credits for roof overhangs on all four sides of the houses of at least 300 mm.	0	0
1 credit for applying silicone or a similar sealant over the roof screws.	0	0
Total for roofing and ceilings:	**2**	**0**
• **Frames for doors and windows** ***(Maximum possible credits: 4)***		
1 credit for installing galvanised steel door and window frames.	0	0
1 credit for applying an undercoat and gloss enamel overcoat to door and window frames.	1	1
1 credit for applying silicone or a similar sealant around the window frames.	1	1
1 credit for applying silicone or a similar sealant around the door frames.	1	1
Total for frames for doors and windows:	**3**	**3**
• **Wood for doors** ***(Maximum possible credits: 2)***		
2 credits for using saligna as opposed to pine external doors.	0	0
Total for wood for doors:	**0**	**0**
SUB-TOTAL FOR BUILDING MATERIALS AND METHODS:	**22**	**17**

CATEGORIES, SUB-CATEGORIES AND FACTORS	CASE STUDIES	
	A	**B**
2. Quality Control *(Maximum possible credits: 8)*		
1 credit for inspection of houses by municipal inspectors on a sample basis, **or**	0	1
2 credits for inspection of houses by municipal and contractor's inspectors on a sample basis, **or**	2	0
5 credits for inspection of houses by municipal and contractor's inspectors on an individual basis and at specified stages of construction.	0	0
1 credit for complying with all sections of the National Building Regulations (NBR).	1	1
2 credits for using contractors who are registered with the National Home Builders Registration Council (NHBRC).	2	2
SUB-TOTAL FOR QUALITY CONTROL:	**5**	**4**
CREDITS OBTAINED FOR TECHNICAL FACTORS: MAXIMUM POSSIBLE CREDITS OBTAINABLE FOR TECHNICAL FACTORS:	**27** **67**	**21** **67**
B. BIOPHYSICAL FACTORS (51 credits) **1. Energy Efficiency** *(Maximum possible credits: 21)*		
5 credits for as many housing units as possible facing in a northerly direction, or for houses facing in as northerly a direction as possible (but not deviating more than 15 degrees to either side of true north).	0	0
3 credits for north windows being equivalent to approximately 20% of the floor area.	0	0
3 credits for locating the rooms with the greatest need for heating on the northern side of the units.	0	0
1 credit for installing airbricks.	1	0
1 credit for the use of compact building forms, i.e square or round, as opposed to rectangular.	1	1
3 credits for designs consisting of semi-detached houses.	3	0
4 credits for designs consisting of fourplex houses.	4	0
1 credit for the installion of prepaid meters in each house.	1	1
SUB-TOTAL FOR ENERGY EFFICIENCY:	**10**	**2**
2. Water efficiency *(Maximum possible credits: 15)*		
5 credits for the installation of multi-flush toilet systems, **or**	0	0
4 credits for the installation of dual-flush toilet systems.	0	0
5 credits for installing cisterns with a flush capacity of 5 litres, **or**	0	0
4 credits for installing cisterns with a flush capacity of 6 litres.	0	0
1 credit for installing stopcock taps on water pipes (outside).	1	1
1 credit for installing stopcock taps near the cistern of the toilet.	0	0
3 credits for installing 'sit-in' baths or showers.	3	0
SUB-TOTAL FOR WATER EFFICIENCY:	**4**	**1**
3. Environmental investigations, policies and systems *(Maximum possible credits: 15)*		
2 credits for input from an environmental specialist with regard to siting of project, **or**	0	2
4 credits for a scoping report, **or**	0	0
6 credits for a scoping report and an Environmental Impact Assessment (EIA) report.	6	0
5 credits for an Environmental Management Plan (EMP) or Environmental Contract being drawn up with the contractor.	5	0

CATEGORIES, SUB-CATEGORIES AND FACTORS	CASE STUDIES	
	A	**B**
2 credits for checking whether, and using, manufacturers and suppliers of building materials and products which have an environmental policy in place.	0	0
2 credits for checking whether, and using, manufacturers and suppliers of building materials and products which have an Environmental Management System (EMS) in place.	0	0
SUB-TOTAL FOR ENVIRONMENTAL INVESTIGATIONS, POLICIES AND SYSTEMS:	**11**	**2**
CREDITS OBTAINED FOR BIOPHYSICAL FACTORS: MAXIMUM POSSIBLE CREDITS OBTAINABLE FOR BIOPHYSICAL FACTORS:	**25** **51**	**5** **51**
C. SOCIO-ECONOMIC FACTORS (22 credits) ***(Maximum possible credits: 22)***		
2 credits for at least one 1-hour meeting with the community covering basic issues relating to sustainable living practices, **or**	0	2
3 credits for at least two 1-hour meetings with the community covering issues relating to sustainable living practices, **or**	3	0
6 credits for 3 or more 1-hour education and training workshops for beneficiaries covering issues relating to sustainable living practices.	0	0
3 credits for employing emerging contractors from within the community.	3	3
3 credits for implementing innovative ideas around waste and job creation.	0	0
2 credits for houses being easily extendable.	2	2
2 credits for a show house/s being constructed with accessible information available regarding the units.	2	2
6 credits for holding quarterly meetings with the community subsequent to their occupation of the houses, for the first year after handover.	0	0
CREDITS OBTAINED FOR SOCIO-ECONOMIC FACTORS: MAXIMUM POSSIBLE CREDITS OBTAINABLE FOR SOCIO-ECONOMIC FACTORS:	**10** **22**	**9** **22**
TOTAL CREDITS OBTAINED: **TOTAL CREDITS OBTAINABLE:**	**62** **140**	**35** **140**

Table 11: Scores obtained by the two case studies

It is evident from Table 11 that case study A received a total of 62 credits out of a possible 140, and B received 35 credits. An explanation of the awarding of credits in each category follows.

4.2.1 Technical factors

This section of the method assesses the technical sustainability of building methods and materials and quality control of the two case studies.

i) Building materials and methods

- **Concrete / cement blocks**

Of the possible 9 points, case study A (hereafter A) received 8, and case study B (hereafter B), 7 points. Both A and B used strong, high-density blocks with a high moisture resistance. Developers and project managers prefer to obtain blocks from larger, reputable firms rather than smaller, emerging block makers. Although they recognise the importance of supporting emerging manufacturers, they state that they have learned through experience that larger, established manufacturers' blocks are less susceptible to water penetration, for the following two reasons:

- the sophisticated machinery allows for greater compaction and compression of the blocks, which results in a higher density; and
- these manufacturers usually include a moisture inhibiting additive in the block mixture.

Developers argue that the use of strong blocks is a fundamental requirement in combatting moisture penetration. The general consensus among them is that the blocks should not be less than 3.5 MPa in strength.

Case study A was particularly vigilant in terms of precuationary measures to keep water and driving rain from entering through the front doors. Both sloping concrete thresholds and wooden weatherbars had been installed. B installed only the thresholds in its units. Developers were adamant that thresholds and weatherbars were necessary finishes, but that the expenses involved in installing these often meant that both could not be installed.

- **Mortar mix and finish**

Both A and B received 3 credits out of a possible 18 in this category. Neither A nor B used lime in their mortar mixes, nor did they include a waterproofing additive. The specification for B included lime and an additive, but this did not happen in practice. The contractor apparently found that the expenses were too great. A matter of concern was that the project manager in this case study expressed misgivings about whether builders were trying to cut costs even further by adding more sand and less cement to the mortar mixture, and that this in fact occurred frequently on building sites. A contact with Federated Timbers noted that for the ideal cited ratio of 1:1:6 (cement:lime:sand), costs would be approximately R20 for 50 kg cement, R32 for 50 kg lime and R36 for 300 kg sand, totalling R88, of which lime accounts for 36% of the total cost. While lime does appear to be expensive, alternatives could be explored. For instance, less lime could be added if a better quality sand than dune sand was used. A waterproofing additive would cost approximately R11 and would be sufficient for one bag (50 kg) of cement. This is substantially cheaper than using lime (Garman, pers. comm., 1999).

A incorporated the bagging method and B the pointing method for finishing off the mortar applications. There was consensus among those consulted in the field that both of these methods are important for ensuring that the mortar is consistently compacted and the mortar joints are properly finished off. Ideally, both methods should be used, but the extra time involved usually meant that at most, only one of these two methods would be implemented.

Neither of the projects allowed the houses time to dry out sufficiently. While developers recognise the need for this, they state it is impossible to apply in greenfields projects where beneficiaries are desperate to move into the houses as soon as they are completed. The water penetration test was not applied in either case study. If it were applied informally, even on a small sample of houses, it would apparently waste valuable time and therefore money, and if it were applied formally by SABS, there would be substantial costs involved.

- **Foundations and damp-proof coursing**

A achieved the full quota of points in this area, and B was awarded 4 out of a possible 6 credits. The difference was that A's foundations had step bricks. The general trend of developers in low cost housing is to incorporate step bricks, as these will ensure that water will be diverted outwards and away from the buildings.

In the projects encountered, adequate foundations were provided for in the building specifications – more so than for mortar and external coating. The problem arises in ensuring that these specifications are applied in practice. It was difficult to ascertain whether or not these had been implemented in projects A and B, as the foundations observed had already been completed.

- **External coating**

A and B both received no credits out of a possible 6. Houses were coated externally with 2 coats of acrylic paint, and nothing more. Once again, cost constraints were the reasons for not applying higher quality external finishes.

The cost of applying a better quality acrylic paint than PVA presently costs R350 per unit (Wiseman, pers. comm., 1999). PVA was used in only one of the projects visited. Cemcrete costs are approximately the same as acrylic paint. The cost (material and labour) of plastering one wall of a low cost housing unit would be approximately R250, while plastering an entire low cost housing unit would be approximately R1000 (Wiseman, pers. comm., 1999). The material costs of skimplaster per housing unit would be approximately R500. Skimplaster saves on labour costs as it is easy to apply (Koch, pers. comm., 1999). The use of skimplaster or plaster was not observed in any of the seven projects visited.

Low cost, greenfields houses cost R400 per square metre to build (Hopkins, pers. comm., 1999). Serious thought should be given as to whether it is not more favourable to have a house that is slightly smaller, but dry, warm and healthy. The savings on houses which are, for instance, $2m^2$ smaller would be R800 per unit. This money could be utilised to plaster external walls.

- **Roofing and ceilings**

A received 2 credits in this category (for houses with dual-pitched roofs) and B received no credits out of a possible 14 for this section. There were no ceilings installed in these houses. In these projects, ceilings were omitted because they were perceived to be too costly. They would require the construction of some form of lattice (over and above the purlins), which would require extra material and labour, as well as the cost of the ceiling itself. Developers in the field recognise the crucial role ceilings play in insulating houses, but insist that their hands are tied by the tight budgets within which they are forced to operate.

None of the units had roof overhangs. Fibre cement sheets are pre-cut. The houses are designed to the maximum possible size and the sheets fit precisely so that they are flush with the walls. It did not appear as if developers felt it important to provide for roof overhangs. Guttering was not provided in these projects, due to the expenses involved.

A had some dual-pitched roofs, which were undoubtedly more aesthetically pleasing than the common mono-pitched roof. Visual aesthetics are significant in that the cumulative visual impacts of these developments on the environment are substantial, given that they are so numerous.

- **Frames for doors and windows**

Both A and B scored 3 out of a possible 4 credits in this category. The door and window frames were not galvanised in either of the two projects assessed. Galvanised steel frames were not used in any of the seven projects observed. Once again, this was due to budgetary constraints. Both case studies applied an undercoat and gloss enamel overcoat of paint, as well as silicone around the edges of the steel frames. This appears to be standard practice in project-linked, greenfields housing projects.

- **Wood for doors**

Neither A nor B were awarded credits as they both installed pine external doors. Other project-linked, greenfields projects schemes opted for saligna or pine doors, with the latter being the prevalent choice. Only one project observed used saligna doors. Once again, the reasons expressed for using pine rather than saligna are cost-related. Saligna doors cost twice the price of pine doors (Brandt, pers. comm., 1999).

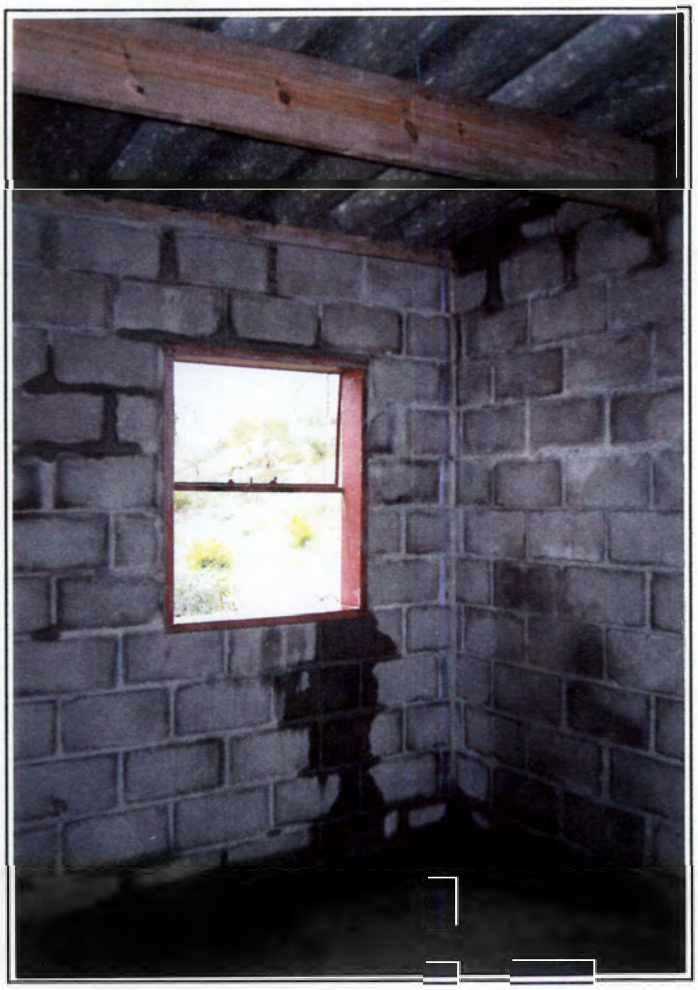
ii) Quality control

Case studies A and B were awarded 5 and 4 points respectively, out of a possible 8. They both received credits for complying with the NBR and for employing a principal contractor who was registered with the NHBRC.

A received 2 credits and B 1 credit out of a maximum possible of 5 for the factor of adequate inspections. A (the larger project) received an extra credit as the construction company employed their own building inspectors who were permanently on site. Both projects incorporated the basic inspection procedures, whereby there were checks for latent and patent defects (and a retention fee of 5% for the first 3 months), sample, ad hoc inspections and an inspection prior to occupation.

The reasons for awarding relatively low points for this factor are as follows. In both projects A and B (and all of the other projects investigated), the inspections referred to in the above paragraph are usually performed under pressure and time constraints. With the emphasis on mass production and rate of delivery of units, many individual houses and defects are overlooked. This is exacerbated by inadequate monitoring of the daily activities of builders. Developers and projects managers in the field expressed concern that short-cuts were being taken on a daily basis, such as watering down mortar and paint mixtures, and generally 'rushing the job'. Even where there are inspectors on site permanently, as with case study A, defects in houses are frequently overlooked. Project managers and contractors hold great responsibility in terms of monitoring quality control effectively.

Photograph 3 indicates what many of these houses looked like inside. Water from the outside frequently penetrates through the external coating and mortar joints, where either have been unevenly applied, or around windows where the mortar has not been applied properly.



Photograph 3: Moisture penetration in a low cost house in a greenfields, project-linked scheme.

Adequate quality control and site supervision are necessary in order to prevent poor finishes and practices from taking place in low cost housing developments.

It is recognised that capacity is a problem in local authorities. Moreover, there is some complacency in municipalities relating to job commitment, as restructuring with the new megacity scheme is a reality and people feel insecure in their present positions. However, one local authority in the CMA (Oostenberg Municipality) is particularly concerned about the inadequate quality control and the poor quality of some low cost houses, and have introduced proactive and innovative measures to address this. They are in the process of training four personnel within their housing department to assist with low cost housing inspections. The director of housing in this municipality has identified this as a matter of urgency and is addressing the issue accordingly (Wyngaard, pers. comm., 1999).

4.2.2 Biophysical factors

The assessment method was applied to the two case studies to appraise certain biophysical factors of sustainability, as described below.

i) Energy efficiency

A received 10 credits out of a possible 21, and B obtained 2 credits. As mentioned in chapter 3, the focus of assessing energy efficiency was to ascertain whether or not principles of passive thermal design had been incorporated into the overall design of the houses.

In neither of the case studies had as many houses as possible been orientated in a north-facing direction. A major determinant in orientating the units was that the front doors faced onto the road, as this is apparently what the beneficiaries prefer. Where there was more than one room in a unit, the most lived-in rooms (during the day-time) were not deliberately built on the northern side of the dwellings.

In both A and B, neither the size nor the positioning of windows had been specifically designed according to the principles of thermally efficient design, i.e. so that the larger windows were north-facing. If this occurred, it was by default rather than intentional design.

Houses in both projects were built in compact forms, and A had duplex and fourplex units which shared walls. Once again, this was not a result of planning according to thermally efficient principles. For instance, houses were built with adjoining walls so that service costs could be minimised, thereby enabling larger units to be built.

Air bricks were installed in A but not in B. The developer of project A viewed these as more important in terms of ventilation than the proponent of project B. There were mixed feelings about this in the field, as some developers and project managers viewed air bricks as significant for ventilation purposes, while others thought they were of little consequence.

Prepaid meters were installed in all of the houses in both A and B, as well as in all the housing units in the other five projects visited. It is standard policy of both Eskom and local authorities to install prepaid meters in low cost houses.

Passive thermal design principles were not incorporated into the overall design of any of the housing units in the seven projects investigated.

ii) Water efficiency

A was awarded 4 credits and B was awarded 1 credit, out of a maximum possible 15 credits. Both projects installed cisterns with a flushing capacity of 9 litres. Availability of these on the market was the deciding factor, and not water efficiency. The student was informed of, but did not visit, a project-linked scheme where 5 litre cisterns were utilised. In this case, an NGO was involved, who had an architect in their employ who had a strong level of environmental awareness. Neither A nor B had multi- or dual-flush toilet mechanisms installed.

Both A and B had stopcocks outside the houses, but neither A nor B had stopcocks near the cisterns of the toilets. One project was visited where these had been installed at the cisterns. The reason given by the project manager was that if leaks in the toilet were detected, this water source (as opposed to the main water source) could be switched off.

B had small 'sit-in' baths installed. A had neither a bath nor a shower, only place for either to be fitted at a later stage. One other project visited had showers installed, and none had baths.

iii) Environmental investigations, policies and systems

Projects A and B were awarded 11 and 2 credits respectively out of a possible 15 for this category. Neither had a policy of using suppliers and manufacturers with an environmental policy and/or an EMS in operation.

A was awarded 6 credits for having undertaken a scoping report and an EIA, and 5 for having an EMP drawn up with the project managers and contractors. A is a large project, and borders on sensitive natural areas, i.e. a river catchment area and dunelands, which made these environmental reports necessary (Lombard, pers. comm., 1999).

B was designated as an area for low cost housing approximately 10 years ago. The input of an environmentalist was utilised then, as the area abuts a wetland area. However, no scoping report, EIA or EMP were drawn up (Lourens, pers. comm., 1999).

It is likely that case study A undertook more extensive environmental investigations as the emphasis and awareness of environmental impacts has increased in recent years, and especially with the promulgation of the EIA regulations in September 1997. The township layout planning for B was done at the end of the last decade, before the EIA regulations had been promulgated.

From consulting with those in the field and visiting projects, it was deduced that local authorities will insist that environmental investigations are undertaken wherever the law requires, and wherever there are sensitive natural areas close to the proposed site/s.

4.2.3 Socio-economic factors

Case study A was awarded 10 and B 9 credits, out of a possible 22 credits. Both had a policy of employing emerging contractors. The only difference was that A's contractor employed emerging contractors as sub-contractors, whereas B had employed an emerging contractor as the principal contractor. The developer for B expressed that there were problems with the cash flow and credit allowance of this contractor, and that in future they would employ well-established contractors and stipulate that they sub-contract to emerging contractors.

Whereas the trend 5 years ago was to employ emerging contractors, developers now feel more comfortable with using more experienced contractors. Emerging contractors could not build at the rate required by mass production, and frequently experienced cash flow problems. Furthermore, quality control can be enforced more effectively by larger companies, who frequently employ full-time inspectors, and who cannot afford to risk losing a good reputation within the industry (Wyngaard, pers. comm., 1999; Madela, pers. comm., 1999).

The best option is now believed to be to utilise emerging contractors and to enhance their skills through 'on-the-job' training. The Department of Public Works now requires, in tendering for public sector projects, that emerging contractors be utilised by established companies (Hill *et al.*, 1999).

The housing units in both schemes were easily extendable. The policy that these are starter units which will need to be extended is supported by these projects, and it seems, by project-linked, greenfields projects in general. Both case studies built show house units and ensured there was a person/s on site who could offer information on the housing units during working hours. A was a bigger project than B with more choices, and therefore more show houses.

Neither project incorporated innovative ideas around waste management and disposal. Rather, the conventional method of the municipalities removing waste once a week was employed.

Projects A and B were awarded 3 and 2 credits (out of 6) respectively for meetings held with the community covering issues relating to sustainable living practices. In both projects, there was a meeting with members from the community prior to their occupation of the houses. This focused on policy issues relating to subsidies and basic information on water, energy and waste issues. A received 3 credits for this factor as the project managers ran a second workshop on energy use and safety, water usage and conservation of a nearby wetland.

However, neither A nor B were awarded any credits for meetings held with the community subsequent to their occupation of the houses, because as far as ongoing and proactive education went, neither project took the initiative of undertaking ongoing workshops with the community.

In only one project was it the policy of the local authority (Blaauwberg Municipality) to remain actively involved with the beneficiaries after occupation of the houses. In this case, meetings were held twice monthly. The focus of these meetings were problems in the housing development identified by the community, innovative waste management and urban greening. These meetings proved invaluable in terms of contributing to the long-term sustainability of the housing project (Madela, pers. comm., 1999).

4.2.4 Summary of results for categories and sub-categories of the assessment method

Table 12 depicts a summary of the results obtained from the application of the assessment method for the various categories and sub-categories.

Technical factors		Biophysical factors			Socio-economic factors	TOTAL
Building materials and methods	Quality control	Energy efficiency	Water efficiency	Environ-mental reports, policies and systems		
22/59 17/59	5/8 4/8	10/21 2/21	4/15 1/15	11/15 2/15	10/22 9/22	
27/67 (40%) 21/67 (31%)		25/51 (49%) 5/51 (10%)			10/22 (45%) 9/22 (41%)	62/140(44%) 35/140(25%)

Key:
Black: Case study A
Red: Case study B

Table 12: Summary of results for categories and sub-categories of the sustainability assessment method.

For technical factors, A and B were awarded 27 and 21 credits respectively (40% and 31% of the total possible credits respectively). A scored extra credits for installing weatherbars on the front doors, step bricks in the foundations and for constructing houses with dual-pitched roofs. However, both scores were low in the important areas of mortar mix and application, external coating and roofing and ceilings. As indicated in chapter 3, these factors are most important in terms of achieving technical and socio-economic sustainability, i.e. houses that are quality, durable, reliable and functional structures. A also scored an extra credit for having a permanent, on site inspector employed by the contracting company.

The credits awarded in the technical category, and the sub-categories thereof, appear to be an accurate reflection of the performance of each case study in the sphere of technical sustainability.

A was awarded 49% (25 of the total possible credits) in the biophysical factors category, and B 10% (5 of the total possible credits). The fact that an EIA and an EMP were undertaken contributed to A's higher mark, as well as the fact that semi-detached and fourplex units were constructed in A. It is highly significant, in terms of biophysical sustainability, that A included an EIA and an EMP. However, the extra points awarded to A for building semi-detatched and fourplex units is misleading as the purpose of building the units in this way was to save money on services and not for energy efficiency reasons. It is important, therefore, to always consider the underlying motivation in the design and planning of low cost houses. Both scores for A and B were low for energy and water efficiency.

A and B's scores for the socio-economic category were 10 and 9 out of 22 credits respectively (45% and 41% of the total possible credits respectively). What was lacking in both cases was education, training and a process of follow-up after the beneficiaries had taken occupation of their units. While it has been the aim of developmental sectors in South Africa to include socio-economic factors, the important socio-economic factor of education and training relating to sustainability is being overlooked in the low cost housing arena.

This chapter has applied the sustainability assessment method to two case studies through the awarding of credits to various factors, and analysed and discussed the results thereof. Conclusions and recommendations can be drawn from this pilot application and analysis, which are discussed in the following chapter.

Chapter 5

5. CONCLUSIONS AND RECOMMENDATIONS

This chapter consists of two sets of conclusions and recommendations. Firstly, conclusions and recommendations which have been drawn as a result of the pilot application of the sustainability assessment method are discussed. These suggest how greenfields, project-linked low cost housing developments can be made more sustainable. Secondly, conclusions and recommendations relating to the future advancement of the sustainability assessment method are drawn. These suggest how the sustainability assessment method developed in this research can be taken forward.

5.1 Conclusions from the pilot application of the sustainability assessment method

The conclusions drawn and recommendations arrived at as a result of the application of the assessment method are discussed below.

5.1.1 Technical factors

i) Building materials and methods

It is evident from chapter 4 that in the category of technical factors, the areas exhibiting the poorest performance in the case studies were mortar mix and finish, external coating and roofing and ceilings.

- **Cement blocks**

The application of the assessment method has revealed that there are no major issues relating to sustainability (as focused on in this study, and notwithstanding recommendation 13) and the cement block, as long as a strong, high quality block is used. The strength of the blocks is directly related to the permeability of the walls of housing units.

Recommendation 1: High quality, strong cement blocks should be used, with a minimum strength of 3.5 MPa.

The investigation also revealed that developers are in agreement that precast concrete thresholds and weatherbars at external doors of the units play a role in keeping water out of the houses.

Recommendation 2: Both a precast concrete threshold and a weatherbar should be installed at/on the front doors of all housing units.

In section 3.4.4, alternatives to the present materials and methods utilised in low cost housing were discussed. It is important to keep researching and exploring these alternatives in order to find the most sustainable materials and methods for low cost housing on the Cape Flats.

Recommendation 3: There should be ongoing research relating to the most sustainable alternative building materials and methods for low cost housing on the Cape Flats.

- **Mortar mix and finish**

The assessment of the case studies, as well as visits to the other projects, indicated that the mix of the mortar and the application thereof was important in determining penetration of water into the houses. Standing in some of these houses on a rainy winter's day was tantamount to being in a fridge. While water is unlikely to seep through a good quality brick, it most certainly will seep through poor quality, badly applied mortar. Such practices are unsustainable in terms of technical quality and social and economic factors. It would prove a more sustainable practice to spend a little more on improving the quality of the mortar in these houses (see section 4.2.1).

Recommendation 4: Attention should be given to improving the mix of mortar, as well as the application thereof. At the very least, a moisture inhibitor should be added to the mortar and the pointing and bagging methods should be utilised.

- **Foundations**

Developers recognise the important role foundations play in structural soundness and overall sustainability of units. The main issue is whether or not the building specifications are adhered to. The challenge lies in monitoring this effectively (see recommendations in section on quality control).

- **External coating**

While the severe cost constraints facing developers cannot be underplayed, skimping of effective external coatings is false economy and unsustainable practice. It undermines the basic principles of sustainability, in that greater costs will be incurred by the beneficiaries for maintenance and space heating of the housing units in the long-term.

Recommendation 5: A more effective external coating should be applied to the houses, even if the houses have to be slightly smaller (see section 4.2.1 for cost analysis).

- **Roofing and ceilings**

The ideal scenario for low cost housing would be to utilise roofing which does not contain any asbestos, and to install ceilings and overhangs in these houses. This would ensure that they are more sustainable structures. Once again, cost constraints do not permit this. If it is impossible for the developer to install ceilings, then he/she should ensure that the beneficiaries are equipped to do so in the future.

Recommendation 6: Beneficiaries should be educated about how to fit their own ceilings in their houses (see section 5.1.3 and Appendix B).
Recommendation 7: Alternative roofing materials to fibre cement with asbestos should be investigated.

- **Frames for doors and windows; wood for doors**

At the very least, solid pine doors should be installed and steel door and window frames should be painted with a primer, undercoat and enamel, and sealed with silicone. Although galvanised steel and solid saligna doors are better options in terms of durability, these factors need to be weighed up against other important factors, such as effective external coatings and mortar mixes. There is no definitive recommendation for either of these two categories. If there have to be trade-offs, it is advocated that priority be given to mortar mix and application, and adequate external coating.

ii) Quality control

A crucial factor in the delivery of low cost housing which is sustainable is the meticulous inspection of each unit and a sense of accountability for this, especially between the contractor, project manager and local authority. This may alleviate problems such as leaving gaps in the mortar in the walls and around windows where water can penetrate, or diluting mortar, external paint or concrete mixes. These practices result in poor quality, less durable structures and impact directly on the quality of the lives of occupants, in terms of health and social costs. Inspections should be much more thorough than they are at present. Because of the pressures imposed by the expected rate of delivery of housing units, houses are often not inspected individually and meticulously, and this often means that quality is compromised.

Recommendation 8: There should be a sufficient number of inspectors on site, so that each house can be properly inspected on an individual basis at specified stages of construction. The lines of accountability between site inspectors and local authorities should be clear and enforced.

5.1.2 Biophysical factors

i) Energy efficiency

Thermal efficiency and passive thermal design principles were definitely not influential in designing and building the housing units in any of the project-linked, greenfields projects assessed or visited. In fact, some project managers and developers seemed surprised by the concept. Developers expressed pressure from the government to focus on the number of units built and the minimum size stipulated ($30m^2$), rather than other issues. The potential for sustainable design has suffered as a consequence of this pressure.

Lack of adequate ventilation and solar input into houses means that occupants may be condemned to poor health and high energy bills. Thermally efficient design can prevent these unsustainable consequences. It cannot be reiterated enough how important it is to implement sustainable building practices in terms of thermal efficiency, especially in the Western Cape. This province, more so than any other, has long, cold, wet and windy winters. While other areas with summer rainfalls may not feel the impacts of these weather conditions, the quality of life of occupants of low cost housing in the Western Cape is undoubtedly being affected, in terms of health and maintenance costs. Saving energy through the thermally efficient design of low cost houses will also be beneficial for the biophysical environment as demands on natural resources, such as coal, will be reduced.

Recommendation 9: Attention should be given to the matter of designing low cost houses which are based on principles of thermal efficiency. National, provincial and local housing authorities should ensure that these principles are incorporated into the design of low cost housing.

ii) Water efficiency

As was the case with energy efficiency, developers' energies are spent on matters such as the mass delivery of houses and addressing budgetary constraints, rather than on planning and designing for the efficient and sustainable use of water. Most of those consulted had not given serious consideration to installing water-efficient devices in the houses. This is a serious oversight given the ever-increasing water shortage in the Western Cape, and if the government's aim is to build truly sustainable low cost housing units.

Recommendation 10: Multi-flush systems should be installed in low cost housing units. Alternatively, cisterns should have a capacity of not greater than 6 litres. Furthermore, occupants of houses should be educated around the sustainable use of water (see section 5.1.3). If bathing facilities are installed, these should comprise 'sit-in' baths or showers.

iii) Environmental investigations, policies and systems

The application of biophysical principles of sustainability in attaining sustainable construction in low cost housing developments is important at a local, regional and national scale. Environmental investigations need to be undertaken and implemented in low cost housing, to ensure that biophysical principles of sustainability are adhered to and the natural environment is protected.

Recommendation 11: Local authorities should undertake at least an initial environmental assessment for every proposed low cost housing development. Based on this, and existing environmental legislation, it should be decided whether more in-depth environmental studies need to be undertaken. Furthermore, an EMP or Environmental Contract should be drawn up with the contractor.
Recommendation 12: In order to ensure that adequate environmental investigations are undertaken, low cost housing developments should be listed as an activity of the EIA regulations that could have a potentially detrimental effect on the environment.

Certain important aspects relating to the achievement of biophysical sustainability in the low cost housing sector, namely supporting environmentally responsible manufacturers, embodied energy, life cycle analyses and ecolabelling of building materials, need to be further investigated and researched.

Recommendation 13: Research should be undertaken relating to life cycle analyses, embodied energy and ecolabelling of low cost building materials.

Recommendation 14: Contractors and developers involved in low cost housing should support environmentally responsible suppliers and manufacturers of building materials.

5.1.3 Socio-economic factors

It is evident that developers and project managers are attempting to address socio-economic issues within severe time and cost constraints. However, ensuring affordability, equitable distribution of costs and good health and quality of life of the beneficiaries will not be achieved if there is not some form of ongoing education and support. Many of the beneficiaries of low cost houses may only have lived in informal structures, with no access to electricity and limited access to potable water. There is a need for ongoing education around the use of electricity and energy, maintenance of homes, urban greening and other issues relating to sustainable living practices.

Recommendation 15: It is strongly recommended that education and training occurs prior to occupation of the houses and thereafter on an ongoing basis, subsequent to the occupation date of housing units. Ideally, these should comprise at least two workshops prior to occupation and at least quarterly workshops thereafter for the following year. The focus of these should be on:

- Maintaining the houses, for example fixing leaks and foundations (when sand is blown away).
- Providing information on affordable, self-help methods of insulating the houses, such as installing ceilings (see Appendix B) and plastering of walls.
- Offering information on urban greening and agriculture on the Cape Flats, especially relating to growing vegetables.
- Achieving efficient water and energy use and managing waste issues effectively.
- Avoiding the health hazards of burning fuels indoors and developing awareness of the importance of adequate ventilation.
- Providing information on methods of extending the units and where to obtain building materials.

- Identifying the lines of communication to follow within the relevant local authority, should there be problems in the future.

This information could be shared in organised workshops, and/or in community newspapers. The iSLP has a bimonthly community newspaper which imparts valuable information on topics such as those listed above. Residents in the community are employed to deliver these newspapers to every home. Alternatively, there are NGOs who specialise in education and training in these areas, who could be employed to fulfil this function (Wight, pers. comm., 1999). Local authorities, with the support of the National Housing Department, could make such programmes compulsory.

5.1.4 Summary of the requirements for the attainment of sustainability

In order for project-linked, greenfields, cement block low cost housing developments to be sustainable, principles of sustainability need to be adopted throughout the development process. Urgent attention should be given to improving **external coating** for units, the **standard of workmanship** in the basic structure of the units, **quality control inspections, water and energy efficiency** and **education and training** of beneficiaries. Measures should be incorporated into the design stage that would ensure **energy and water efficiency. Initial environmental investigations** or **EIAs** should be undertaken at the proposal stage of each and every low cost housing project.

This may translate into building units which are one or two square metres smaller due to the extra costs involved – but the result would be warmer, healthier, more durable homes and an adequately protected natural environment. If these issues are ignored, low cost housing developments that can sustain themselves will not be created, and the outcome may well be to create slums of the future.

5.2 Conclusions about the sustainability assessment method

The sustainability assessment method has been demonstrated through its pilot application to two case studies. This application has indicated that the assessment method is a feasible, workable method. The goal of the assessment method was achieved, i.e. to assess selected aspects of the sustainability of greenfields, project-linked, cement block low cost housing developments on the Cape Flats and draw conclusions and recommendations from the assessment. This was accomplished by means of:

- appraising the case studies through the pilot application of the sustainability assessment method;
- obtaining results based on this appraisal;
- analysing these results;
- drawing conclusions and recommendations from these results.

The conclusions and recommendations can contribute towards the attainment of sustainability in the low cost housing sector on the Cape Flats, if they are implemented.

Since the pilot application of the sustainability assessment method has indicated that it is workable, it would be good practice for it to be further tested and refined in the field. The assessment method should be applied to more case studies within the Cape Flats area, and refined and developed as it is applied. Local authorities could utilise the sustainability assessment method described in this dissertation, or a refined version thereof, in their inspection and quality control procedures of low cost housing projects to improve the sustainability of housing projects.

<u>Recommendation 16:</u> The sustainability assessment method should be refined and tested on further case studies in the field.
<u>Recommendation 17:</u> Local authorities in the CMA should consider utilising this, or a similar sustainability assessment method, as part of their inspection and quality control procedures, in order to ensure that the sustainability of low cost housing is improved.

Table 13 overleaf consists of a summary of the recommendations of this concluding chapter.

NUMBER	RECOMMENDATION
1	High quality, strong cement blocks should be used, with a minimum strength of 3.5 MPa.
2	Both a precast concrete threshold and a weatherbar should be installed at/on the front doors of all housing units.
3	There should be ongoing research relating to the most sustainable alternative building materials and methods for low cost housing on the Cape Flats.
4	Attention should be given to improving the mix of mortar, as well as the application thereof. At the very least, a moisture inhibitor should be added to the mortar and the pointing and bagging methods should be utilised.
5	A more effective external coating should be applied to the houses, even if the houses have to be slightly smaller.
6	Beneficiaries should be educated about how to fit their own ceilings.
7	Alternative roofing materials to fibre cement with asbestos should be investigated.
8	There should be a sufficient number of inspectors on site, so that each house can be properly inspected on an individual basis at specified stages of construction. The lines of accountability between site inspectors and local authorities should be clear and enforced.
9	Attention should be given to the matter of designing low cost houses which are based on principles of thermal efficiency. National, provincial and local housing authorities should ensure that these principles are incorporated into the design of low cost housing.
10	Multi-flush systems should be installed in low cost housing units. Alternatively, cisterns should have a capacity of not greater than 6 litres. Furthermore, occupants of houses should be educated around the sustainable use of water. If bathing facilities are installed, these should comprise 'sit-in' baths or showers.
11	Local authorities should undertake at least an initial environmental assessment for every proposed low cost housing development. Based on this, and existing environmental legislation, it should be decided whether more in-depth environmental studies need to be undertaken. Furthermore, an EMP or Environmental Contract should be drawn up with the contractor.
12	In order to ensure that adequate environmental investigations are undertaken, low cost housing developments should be listed as an activity in the EIA regulations that could have a potentially detrimental effect on the environment.
13	Research should be undertaken relating to life cycle analyses, embodied energy and ecolabelling of low cost building materials.
14	Contractors and developers involved in low cost housing should support environmentallly responsible suppliers and manufacturers of building materials.
15	Education and training relating to sustainability prior to occupation of the houses and thereafter on an ongoing basis should take place. Ideally, this should comprise at least two workshops prior to occupation and at least quarterly workshops thereafter for the following year.
16	The sustainability assessment method should be refined and tested on further case studies in the field.
17	Local authorities in the CMA should consider utilising this, or a similar sustainability assessment method, as part of their inspection and quality control procedures, in order to ensure that the sustainability of low cost housing is improved.

Table 13: Summary of recommendations of concluding chapter.

This final chapter of the dissertation has discussed the conclusions and recommendations drawn as a result of the pilot application of the sustainability assessment method, as well as conclusions and recommendations regarding the workability of the assessment method and its application in the future.

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Appendix A

Ncdlona, Mbulelo	Regional Co-ordinator, Habitat for Humanity	363 0776	20 July 1999
October, Carl	Director, Provincial Housing Inspectorate, Western Cape	483 3489	2 August 1999
Parish, Kevin	Sales Manager, DBL Cement Products	905 1665	2 July 1999
Penman, Alison	Technical Specialist, Paint Division, SABS, Pretoria	012 – 428 7911	5 August 1999
Pritchard, Kevin	Manager, Plascon Paints	083 625 6280	21 July 1999
Rendell, Alastair	Architect, Mammon Rendell	448 9064	8 June 1999
Schreuder, Jan	Director, Peninsula Construction	949 8120	4 August 1999
Steers, Abraham	Technical Specialist, Timber Division, SABS, Pretoria	012 – 4287911	5 August 1999
Taylor, Jeremy	Manager, Water Rhapsody	083 753 3556	27 July 1999
Visser, Eric	Technical Specialist, Building Materials Division, SABS, Pretoria	012 – 428 6113	5 August 1999
Wight, Astrid	Architect, Development Action Group	448 7886	9 June 1999
Wiseman, Gavin	Senior Officer, Housing Projects, Tygerberg Municipality	918 7259	14 June 1999
Wyngaard, Dion	Housing Officer, Oostenberg Municipality	900 1529	10 August 1999

APPENDIX A:
List of Personal Communications

Name	Position and Organisation	Contact Number (in Cape Town unless specified otherwise)	Date interviewed
Appleton, Gary	Development Consultant, Caleb Consulting	424 5509	14 June 1999
April, Isaac	Building Inspector, Oostenberg Municipality	900 1529	29 June 1999
Brandt, Derek	Store Manager, Peninsula Construction	949 8120	28 July 1999
Bright, Richard	Manager, BT Coating	015-297 0926	10 August 1999
Callaghan, Mark	Director, Environmental Planning, South Peninsula Municipality	710 8017	20 September 1999
Dick, Peter	Manager, Housing Development, South Peninsula Municipality	704 7237	17 June 1999
Dinnie, Alan	Principal Officer, Housing Projects, Tygerberg Municipality	918 7268	8 June 1999
Garman, Kenneth	Self-employed, Electrical Engineer	852 8839	10 August 1999
Henwood, Nic	Senior Researcher, Industrial Health Group, University of Cape Town	650 3508	8 July 1999
Hopkins, John	Project Manager, Jondev	082 780 0807	29 July 1999
Ilsley, Mark	Engineer, Engineering Laboratory, SABS, Cape Town	689 5511	5 August 1999
Johnston, Robert	Director, Housing Development, South Peninsula Municipality	704 7258	17 June 1999
Koch, Guenter	Masonary Consultant, Concrete Manufacturers Association	461 2511	6 July 1999
Lombard, Dupre	Planner, Macroplan	975 1307	23 August 1999
Lourens, Adrian	Planner, Macroplan	975 1307	18 August 1999
Madela, Kholiswa	Senior Housing Officer, Blaauwberg Municipality	550 7511	12 August 1999
Malotane, Dawn	Contractor/Project Manager, Malotane Building Services cc.	704 1993	18 June 1999
Mc Carthy, Roger	Sales Manager, Penny Pinchers, Montague Gardens	551 2420	5 August 1999
Molloy, Sean	Civil Engineer, GIBB Africa	469 9100	11 August 1999

Appendix B

APPENDIX B:
Installation of a Ceiling (Integrated Serviced Land Project, 1999)

HERE IS AN INEXPENSIVE WAY OF PUTTING A CEIL-ING INTO YOUR HOUSE

Before you start make sure your roof is not leaking.

1. You can paint on bitumen to block the holes in the roof. Use plastic bags to block the holes between the top of the walls and the roof.
2. Use nails to hang wire from one side of the room to the other – about 30cm apart. The ceiling will rest on top of the wire.
3. Put 2 or 3 sheets of card-board on top of the wires. Leave some space between the cardboard and the roof.
4. Use plastic tape to join pieces of plastic together to make large sheets of plastic. Put these sheets between the cardboard and the wire. There must be no holes in the plastic. Steam from cooking can go through holes and make water in the ceiling.
5. Put a single layer of cardboard under the plastic and on top of the wires. You can paint this cardboard if you like.
6. You can put up thin planks of wood to stop the ceiling from sagging.